
WHAT TRANSPORT FOR CAMBRIDGE?
CAMBRIDGE
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Marcial Echenique
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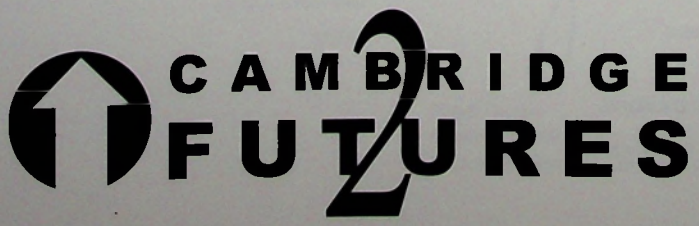

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Foreword

Cambridge Futures is a unique partnership of business, local government and the academic world. This report and the accompanying DVD is the group's second research project. it follows the award-winning land use study published in 1999. This did much to influence the outcome of the development plan debate in the Cambridge Sub-region.

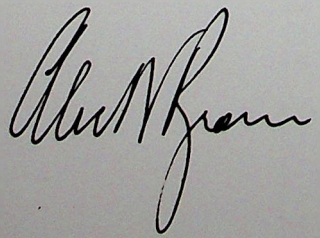
Transport is now the fundamental issue in the development of sustainable growth within the Sub-region. *What Transport for Cambridge?* considers the environmental, economic and social impacts of four single options and a complex combination of these. In doing so, it ranges beyond our current planning horizon to inform the community of the implications of the decisions it will have to make.

What Transport for Cambridge? promotes no single solution. There are, indeed, no definitive answers. But we hope that it will provide a basis for the informed debate and decision making that will enable us to build on the fragile foundations of the knowledge economy and bequeath a sustainable legacy for those who follow us.

The rationale for Cambridge Futures, as outlined in the foreword to our first report, remains as fresh and valid as when it was first written:

'The Cambridge region has a role that stretches far beyond its administrative boundaries. It reaches deep in to the global economy, into research and invention everywhere, into the ideas that are shaping our lives and our world. Our common goal, for all the wide range of interests of the participants, has been the fusion of sustainable development with our local, national and international functions.'

We thank all those organisations and individuals who, subscribing to those objectives, have contributed to this study. In supporting us, they have faithfully adhered to the principle that, whatever their own preference and interests, it is the wider concerns of the entire community that should take precedence in the shaping of the future Cambridge.



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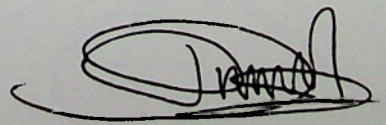

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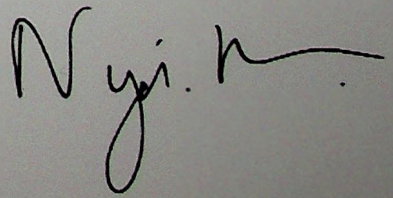

Nigel Brown
Chairman NW Brown Group
Chairman Greater Cambridge Partnership

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1. Background

1.1 About Cambridge Futures

Cambridge Futures is a non-profit making group of local business leaders, politicians, local government officers, professionals and academics who have been looking at the options for growth in and around Cambridge since 1996.

The first Cambridge Futures study, published in 1999[1], considered seven options for the future physical form of the area within a 25 mile radius of the city (see figure 1.1). Each option was studied with sophisticated computer models and the results analysed in economic, social and environmental terms. It was presented to the public in the form of a detailed report, an animated video and a series of exhibitions. There was widespread media coverage and public interest.

The first Cambridge Futures study is widely acknowledged to have played an invaluable role in the planning debate open about the future of the area. The case for considering a far wider area than that contained within the statutory boundaries was accepted and led to the definition of the Cambridge Sub-region. The exploration of use of green belt areas for development led to the review of the green belt boundary. We believe that our work has helped to create a consensus on the way forward for the development of the Sub-region.

The Royal Town Planning Institute gave Cambridge Futures the year 2000 award for Planning Innovation. The method employed in the study is now widely acknowledged throughout the world.

Following the success of the first study, Cambridge Futures has now focused on transport as the critical issue facing the Cambridge area. This second study has followed the format of the earlier work - proposing a range of options for solving the problem and assessing their impact on the local economy, social equity and environment.

Over £100,000 plus a similar amount of funding-in-kind has been donated by the sponsors listed at the front of this report and by individuals. The funds have been used to employ a full time researcher, a part time administrator and for covering other ancillary costs.

Figure 1.1 Cambridge Sub-region

Cambridge Futures is managed by an Executive Group listed at the front of this report. The research team is based at the University of Cambridge Department of Architecture.

This report aims to inform the public on a range of transport options and their economic, social, and environmental implications for the quality of life in the region. It is hoped that discussion of the options will lead to a consensus that will aid the planning process.

For the past half century the development of the City of Cambridge and surrounding areas has been severely constrained. The Holford report [2] proposed to limit the development of the City and surrounding villages. It was recommended that Cambridge should be limited to 100,000 people. This figure was just about maintained (108,000 in 2001)[3] as a result of restricting housing development and a strong green belt policy. Employment, especially manufacturing, was encouraged to locate or re-locate elsewhere in the region. By 1969 the constraints on employment growth were relaxed following the Mott report (1969)[4] that allowed science and university based industries to located in the City. This opened the way for the Trinity Science Park and similar employment clusters which led to the birth of the Cambridge Phenomenon[5]: There was a surge of growth of high-tech firms and associated services employing over 23,000 people. Today, this forms the backbone of the Sub-region's successful knowledge based economy.

The contradictory nature of the policies that allowed employment to grow but constrained the growth of housing, has had serious consequences: house prices have risen substantially. It has been necessary for increasing numbers of people who work in Cambridge to live beyond the green belt, where cheaper housing more than offsets the cost of travel into Cambridge. Medium and lower income groups have been displaced because they can no longer afford property prices in Cambridge unless protected by social housing. The population growth in surrounding villages and market towns has been amongst the highest in the country. As a result there is a daily influx of workers from outside the City: this outnumbers the resident workers.

Traffic congestion has grown as a result of more people commuting by car, causing delays, accidents and pollution: their dispersed origins means that public transport is unviable for many of these journeys.

The continued success of the Cambridge Sub-region is now under threat. Segal Qunice Wickstead[6] have reported that difficulties in recruitment and shortages of available premises are the major threats to future economic growth in the Sub-region. Recruitment is not helped by increased housing and transport costs faced by incomers.

In order to maintain and improve the economic opportunities for Cambridge as well as increasing the social equity of the area while protecting the environment, the Regional Planning Guidance[7] advocated a change in the policies, alleviating the constraints on the development of the Cambridge Sub-region. New housing should be located where the jobs are: in the City and, subject to a review of the green belt, by extending the City. New housing, beyond the green belt, should be located in a new settlement and in the market towns and large villages.

The recommendations of the Regional Planning Guidance have been taken further in the Revision of the Structure Plan of Cambridgeshire and Peterborough[8]. The removal of the 50 year constraints on the size of Cambridge should increase the population of the built up area of Cambridge by one third from 1999 to 2016. Due to the increase of households and employment, the size of the urban area will expand into the green belt with more people travelling within the built up area.

The release of the development constraints in carefully chosen areas, aims to minimise the adverse effect of the expansion. It is hoped that the proposed urban extensions will be carefully designed to maintain the characteristic green 'wedges' that connect the open countryside with the city centre. The planned major expansion of Cambridge offers the possibility of adding new areas of quality to the existing urban fabric. There are precedents such as the 18th Century expansion of Georgian London and the New Town of Edinburgh that improved the quality of the cities rather than detracting from them.

The great difficulty with urban expansion is the increase in congestion. In a historic city it is very difficult to increase the capacity of the road network to accommodate extra cars. Other means to cope with the essential travel should be explored. Every trip implies a transaction and this is essential for sustaining the economy. The suppression of travel leads to the suppression of economic growth of the region, which in turn leads to an impoverishment of the population. One of the aims of good planning is to encourage transactions that lead to economic growth, but in a form that is least harmful to the environment. This may entail restricting some forms of travel in the more congested areas, whilst providing alternative forms of travel which avoid harming social and economic prosperity.

The 2003 Structure Plan[9] includes significant transport proposals and there is a government support to deliver A14 improvements and rapid transit in the Huntingdon to Cambridge corridor. However, these measures may not be sufficient to meet the large increase in travel demand that will arise as a result of the increasing local population. Cambridge Futures has therefore examined a range of options providing further transport capacity in addition to schemes that are already committed.

1.3 Methodology

The Options

The Base Case assumes the full implementation of the land use policies in the Structure Plan 2003[10] and the committed transport improvements [11] (see Chapter 2). It represents the most likely land use scenario to become reality. The options represent the Base case plus further transport measures. Each shows what could be achieved by focusing entirely on a single transport instrument. These include non-motorised modes (cycling and walking), public transport, road building, (in the form of an orbital highway), and demand management (represented by congestion charging). This aims to show what each approach can achieve independently. There is also a combined option that examines how all four of the options would work together. The options are broadly consistent with the transport policies in the Structure Plan, which promote cycling, walking and high quality public transport, and recognise the need to cater for orbital movements, and provide demand management.

The possible effects of new technology, such as increased teleworking, and of 'soft measures,' such as 'green travel plans,' have not been tested. Their effects on travel in peak periods are not yet well understood, but they are unlikely to solve the problems of traffic congestion in Cambridge. The simulation model includes a 5% spreading of peak hour trips to reflect more flexible travel behaviour.

Simulation Models

Following the first Cambridge Futures (1999) [12] study, the same computer simulation models (MENTOR/SATURN) [13] have been used for forecasting and assessing the likely outcomes of alternative options (See Appendix A).

These models have been used by Cambridgeshire County Council to test the Structure Plan policies. This represents the Base Case against which this study compares the options. Cambridge Futures has added transport elements to this base simulation model to represent each of the options. The options have then been run by the County Council and the results assessed by Cambridge Futures.

As illustrated in figure 1.2 the models simulate the working of two inter-related markets; the land market and transport market. Firms and households demand business floorspace and dwellings at different locations. The interaction with the available supply will determine the price of buildings. If the demand in a particular location is high, the prices will rise. If, on the other hand, the demand is low, the prices will reduce. This change in prices will affect the demand for location by firms and households. The model calculates the prices in several iterations until it converges to a stable set of prices within the Sub-region. Once the location of firms and households is established, the transport

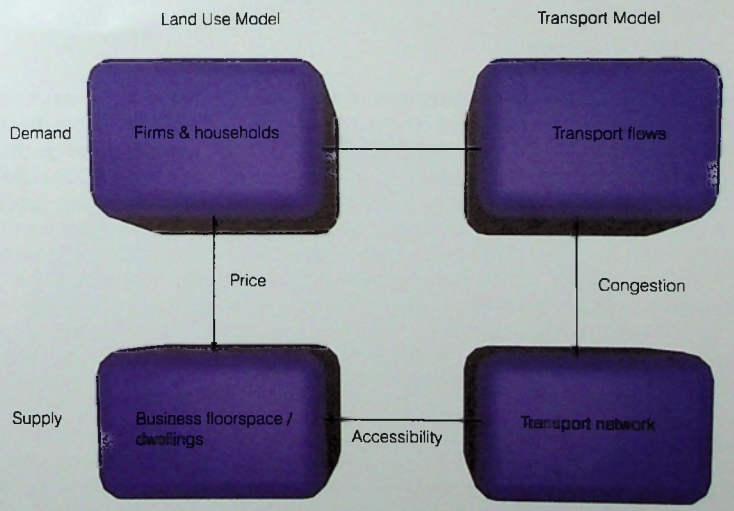


Figure 1.2 Computer simulation model

model estimates the number of trips for different purposes. The trips are assigned to the transport network, estimating the number of trips by car, public transport, walking and cycling. The model proceeds to calculate the delays due to traffic congestion that may affect the utilisation of different transport modes. The model uses an iterative approach to reach an equilibrium where no further changes arise in the use of different modes due to traffic congestion. The resulting transport costs are fed back into the land use model as an accessibility value for each pair of locations. This has an effect on the demand for location by firms and households. The model is 'cycled' forward into the future to represent the interaction between land use and transport.

Initially the model was set up to reproduce the situation in 1991 (for which there is a verifiable, consistent and relatively complete set of census and traffic survey information) [14]. The model was used to simulate the years 1996 and 2001. The results have been checked against available, but partial, recent survey data. It would be possible to check thoroughly and adjust the model accordingly when the complete census information for 2001 becomes available in the future.

The year 2001 constitutes the base year for comparisons between future scenarios and existing conditions, the model has then been run at 5 year periods (i.e. 2006, 2011, 2016 and 2021). This base run represents the implementation of the Cambridgeshire Structure Plan policies and provides the bench mark against which the other options have been compared, with transport assessment for years 2011 and 2016. The majority of the outputs are illustrated for the year 2016 - the final year of the Structure Plan.

The inputs to the model are of two types:

- external projections: Includes the growth of exporting firms (i.e. high-tech, higher education and related business services); and of overall numbers of households and jobs. In the Base Case, the overall values correspond to those forecast by the Cambridgeshire County Council.
- policy options: include the land allocated in each zone for dwellings and business floorspace (including the numbers of dwellings and area of floorspace), as indicated in the Structure Plan, the committed improvements to the transport networks such as new or expanding highways, new public transport, etc. and also taxation or subsidies for the use of the land or transport. In the Base Case, the inputs represent the Structure Plan assumptions.

The resulting outputs from the land use model give for each zone (see figure 1.3) the following:

- Location of households by socio-economic groups, car ownership and size of households.
- Location of employment by type
- Housing rental and cost of living by household type (includes housing, transport and all other goods and service costs).
- Floorspace rental and production costs by employment types (includes labour, rental, transport and other input costs).

The resulting outputs from the transport model forecast for each pair of zones the following:

- Trips by purpose: to work, to education and other trips by household types.

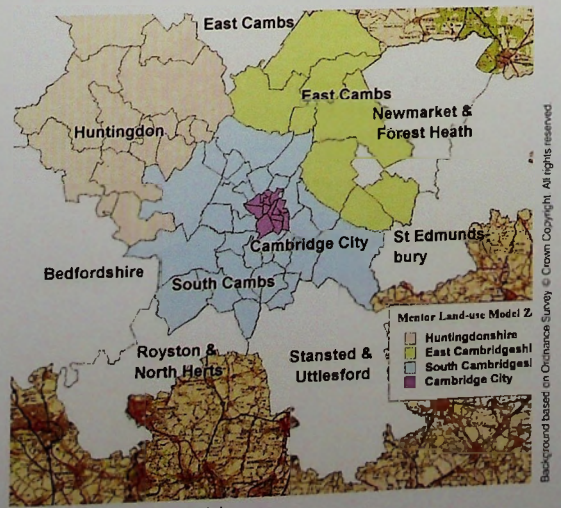


Figure 1.3 Computer model zones

- Trips by mode: car, bus, rail, high quality public transport, park and ride, cycling and walking.

Finally the number of car trips using the highway network are simulated through a SATURN model [15], which is able to estimate the traffic delays at junctions on the network distributor roads within the built up area of Cambridge.

Alternative options

The base option against which all other options are compared, is the one that assumes the implementation of the Structure Plan. The other options represent transport policies that give priority to a single or to a combination of modes of transport. The following have been considered:

Base Case. This option allocates land for development and introduces new transport investment (A14 expansion and guided bus) as specified by the Structure Plan (2003)[16] and the accompanying Implementation Plan[17].

Cycling and Walking Option. This option was not simulated separately as the model is not sufficiently sensitive to local factors that may affect cycling and walking. It was assumed that measures for extending the cycling and walking network would be implemented to retain the ease of travelling by these modes as the size of the urban area expands, and increase, if possible, the percentage of trips using these modes.

Public Transport Option. This involves the extension of the high quality public transport (HQPT) network included in the Base Case, to serve the City Centre and surrounding areas, permitting public transport running in segregated ways, including tunnels to provide uninterrupted service.

Highway transport option. This involves the development of an orbital road, with a new highway around the south and east of Cambridge, as the north and west would be served by the expanded A14/M11 trunk roads. An orbital may reduce the need for some car trips to travel through the City, and would link the proposed peripheral development and improve access to park and ride sites.

Congestion charging option. This involves the introduction of peak period charging for vehicles entering the built up area of Cambridge. The intention is to reduce the demand for car travel.

Combined option. This involves testing all of the options at once to see whether there are synergies that allow the options to work more effectively together.

It is important to note that the Base Case is included as an integral part of all of the other options. Up to 2011, the land use output for all the options is identical. But at 2011, alternative transport options are introduced, changing the transport market as users switch to different transport modes that, in turn, affect the accessibility of different zones. By 2016 the land use output is different for each option as the transport policies affect the land market, changing the location of firms and households. The resulting transport use in 2016 is thus not only affected by the transport policies but also by the changes in land use. Finally, the land use model is run for 2021 to explore the longer term impact of the transport policies on land use. This may give an indication, through the changes in rental values, of where there is likely to be a strong demand for development beyond 2016. Appendix B includes the transport flows for options.

Assessment

The assessment of the options is performed in two ways: feasibility and sustainability. Feasibility assessment tries to determine to what extent the option is viable, not only technically but economically. It uses cost benefit analysis, as recommended by the Treasury for Public funding of infrastructural projects (HM Treasury 2003), to compare the capital costs of implementing the options with the benefits generated by the options. The benefits, measured in monetary terms, are calculated for users of the transport system, operators and government [18]. The sum of all the benefits are compared against the cost of implementation to estimate the rate of return on the investment. There are two rates: social and private. The social rate includes all valued benefits to society, while the private rate includes only the benefits accruing to the investor in the transport system.

The user benefits are calculated using conventional cost-benefit analysis - as savings in money and time of travel, (estimated at £6 per hour for the purpose of work and commuting, and £4 per hour, for education and personal business), as a result of implementing the options in comparison to the base case. The user benefits can be negative - users can be worse off in monetary terms as a result of the option (e.g. congestion charging) or worse off in terms of travel times. Cambridge Futures has calculated the benefits for each of the tested options. In addition, the study calculated the convenience of transport, evaluated in monetary terms. The overall measure also includes the changes in the amount of travel resulting from variations in cost, time and convenience. Technically, the method involves the calculation of the change in user 'surplus' - that is the difference between what transport users are willing to pay (demand) and what they are actually paying for transport. The payments here include all the costs involved – money, time and convenience per unit distance. If the costs are reduced the user may travel further to reach better opportunities. This implies a change in mobility that leads to a greater benefits. The user surplus calculation takes all of these factors into account.

The transport operators will benefit from changes in net revenue (after subtracting the cost of the operation). However, for the purpose of this study, the changes of benefits to the bus and rail operators, resulting from the introduction of an option, have not been calculated. In other words, it has been assumed that their operation costs would not be fundamentally altered. This assumption is unrealistic for Public Transport, as the bus companies would benefit from a more fluid system resulting from the proposed investments in tunnels, congestion pricing, etc. These benefits would include savings in labour and vehicles as the companies would require less of them to cope with the demand. The only operator benefits estimated in the study have been those to the public or private operator that may run the Congestion Charging Option. The net revenues are estimated and included in the appraisal.

Government benefits would include changes in taxation and subsidies resulting from the implementation of policies, in the study only the changes in fuel taxes have been considered as part of the appraisal (at 45.8p per litre). The addition of the annual benefits to users, operators and government are compared against the investment cost of the option to obtain the social rate of return.

From a sustainability point of view, the options are assessed in terms of:

- Economic efficiency: This considers the economic impact of the option measured by changes in prices, for consumers (households) and producers (mainly exporters). This form of appraisal is more comprehensive than the standard cost-benefit analysis used in transport assessment (as calculated in the feasibility assessment above), as it not only measures the benefits to transport users, but to the economy as a whole.

- Social equity: This considers the distributional impact of the options - the cost and benefits for different socio economic groups. It also considers the spatial segregation of socio-economic groups.

- Environmental impact. This uses energy consumption as a measure of the impact on the global environment. Lower fuel consumption represents less use of unrenewable energy and lower carbon emissions, which are thought to contribute to climate change. The SATURN traffic model produces estimates of overall fuel consumption by traffic for the Sub Region. This partly depends on total distance travelled but also on the amount of traffic congestion. Engines are less efficient when accelerating and decelerating. Local air pollution is also related to the amount of traffic and is made worse by congestion. Local environmental effects have been assessed on the basis of professional judgement rather than surveys and calculation. Noise from vehicles is related to a number of factors, particularly the volume of traffic, distance of properties from the source, and on the amount of screening by physical barriers such as earth, and other properties. Other significant local effects include visual intrusion on the landscape, and the effect on the townscape.

The comparison of the options, (Chapter 8) includes an Appraisal Summary Table that compares the options against the Base Case using the impacts recommended in the Guidance for Multi-modal Studies. [19]


oakington new settlement
A14
new chesterton station
city centre
cambridge airport
M11
grantchester meadows
addenbrookes hospital
railway line
guided bus
existing park & ride
proposed development
background
base
cycling & walking
public transport
orbital road
congestion charge
combined

2. The Base Case: The Structure Plan

2.1 Description

The Base Case assumes full implementation of the land use policies in the Cambridgeshire and Peterborough Revised Structure Plan [20] by 2016, and the implementation of the committed transport schemes by 2006 [21]. The Structure Plan, aims to "support the continued growth of research and development, and the knowledge base economy...whilst protecting and enhancing the environmental qualities of the area". The development strategy for achieving the stated aim in the Sub-region includes the allocation of 47,500 new dwellings between 1999 and 2016 in four areas: 8,900 within the Cambridge built up area; 8,000 on the edge of Cambridge (subject to a review of the green belt boundary); 6,000 in a new settlement at Longstanton/Oakington and 24,000 in market towns and large villages. 23,000 of the new dwellings are to be located where planning permission has already been given or where local councils have allocated land for development. Table 2.1 and figure 2.1 show the numbers of dwellings in each district from 2001 to 2016. The dwellings represent a house of average size for the Sub-region.

As illustrated in figure 2.2, the new areas of development around Cambridge are concentrated in the north, south, east and west with the largest concentration on and around the proposed redevelopment of Cambridge airport which will go on beyond 2016. Outside the urban area, the main development is located in a new settlement of up to 6,000 dwellings by 2016 at Longstanton/Oakington (11km north west of Cambridge).

New Employment floorspace is permitted in the areas that have allocated land and is illustrated in figure 2.3 and table 2.2. The bulk of the new floorspace is on the edge of the built up area in the Southern fringe (around Addenbrookes Hospital), in the West (in the Cambridge University West Site), in the North (in the Anglian Water/Chesterton sidings, near the existing Science Park and Business Park) and in the East (in the airport area). (The floorspace illustrated does not include buildings for public services.) It is anticipated that much of this employment growth will be 'home grown'; fuelled by the expansion of high-tech businesses rather than as a result of a re-location of activity from elsewhere.

Transport improvements considered in the Base Case (see figure 2.2) include the recommendations of the Cambridge to Huntingdon Multi Modal Study (CHUMMS) [22], to expand the capacity of the A14 between the A1 and the Fen Ditton interchange, and the introduction of a rapid transit from Huntingdon to Cambridge, using in part, the abandoned rail links between St.Ives and Cambridge and between the rail station and the

	2001		2006		2011		2016	
Camb. City	44	(100)	46	(104)	50	(113)	56	(126)
South Cambs	55	(100)	59	(109)	59	(100)	71	(129)
East Cambs	30	(100)	32	(107)	32	(100)	34	(113)
Hunts.	67	(100)	71	(106)	71	(100)	76	(113)
Total	196	(100)	208	(106)	212	(112)	237	(121)

Table 2.1 Base Case: Location of dwellings x 1000 (2001 = 100)

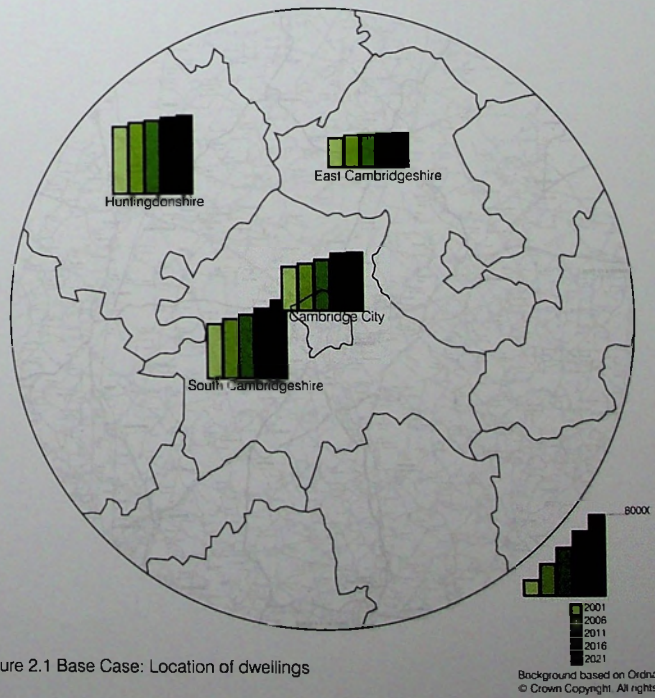
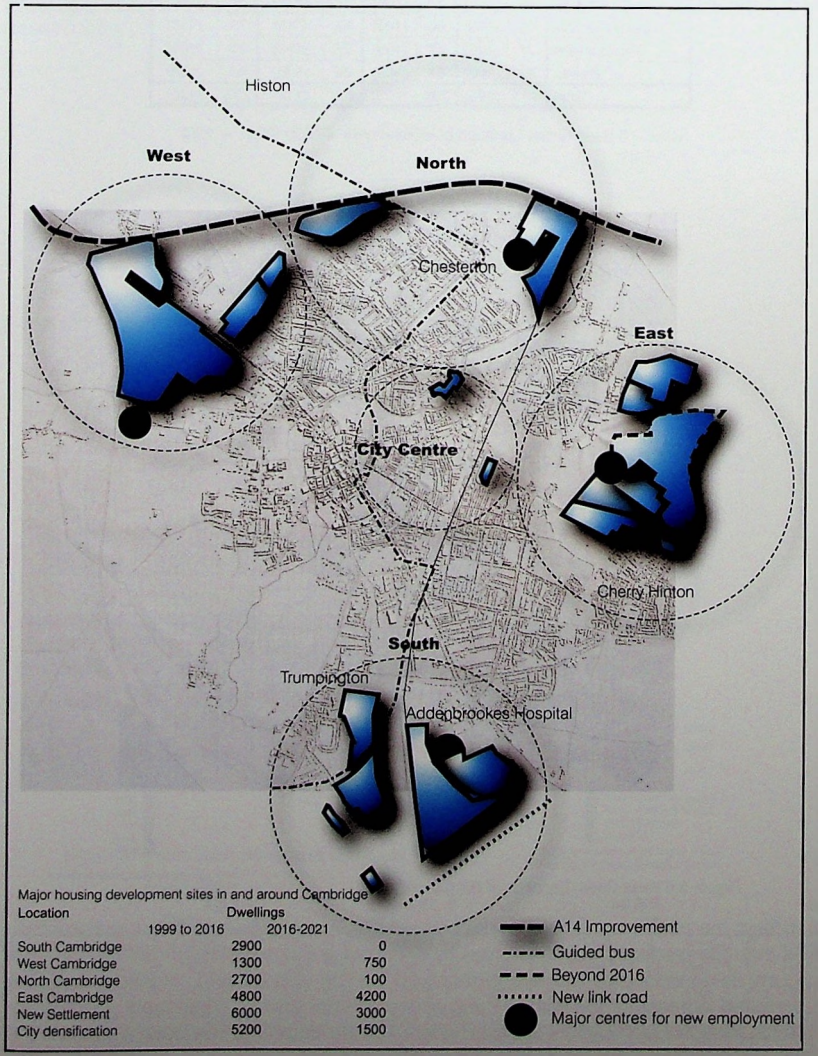


Figure 2.1 Base Case: Location of dwellings

Trumpington park and ride site. The County Council is actively promoting guided buses as the preferred transport system for this scheme. Given that this has central government support and is at an advanced stage of planning, it was assumed that a High Quality Public Transport (HQPT) guided bus system will be developed from Huntingdon, serving the new settlement at Longstanton/Oakington, entering Cambridge city centre via Milton Road (with bus priority measures) and from there to the rail station. From the Rail Station to the Trumpington park and ride, the guided bus uses the right of way of the abandoned Cambridge to Bedford railway line.



Major housing development sites in and around Cambridge

Location	Dwellings 1999 to 2016	Dwellings 2016-2021
South Cambridge	2900	0
West Cambridge	1300	750
North Cambridge	2700	100
East Cambridge	4800	4200
New Settlement	6000	3000
City densification	5200	1500

Figure 2.2 Base Case: New development area around the edge of the built up area of Cambridge

	2001		2006		2011		2016	
Camb. City	1145	(100)	1189	(104)	1223	(107)	1275	(111)
South Cambs	1048	(100)	1127	(108)	1232	(118)	1279	(122)
East Cambs	499	(100)	500	(100)	500	(100)	500	(99)
Hunts.	1409	(100)	1429	(101)	1438	(102)	1486	(106)
Total	4101	(100)	4245	(104)	4293	(107)	4540	(111)

Table 2.2 Base Case: Business floorspace- square metres x 1000 (2001 = 100)

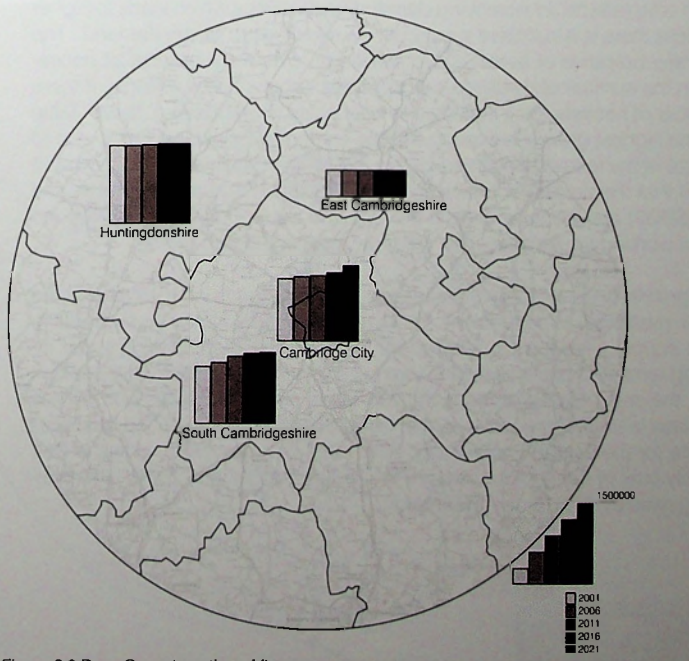


Figure 2.3 Base Case: Location of floorspace

The Base Case includes the development of a new station at Chesterton sidings with a connection to the guided bus scheme, a link road between Hauxton Road (A1309), and Addenbrookes with a connection to the proposed developments at Clay Farm and South of Addenbrookes, also north facing slip roads for M11 junction 13.

Table 2.3 and figure 2.6 show that from 2001 to 2016 it is estimated that there will be 17,000 more households living in the city (+34%) and 16,000 more households living in the South Cambridgeshire district (+30%). The socio-economic structure of the population is illustrated in figure 2.7 and table 2.4. The number of households per dwelling depends on the supply and demand for housing. Generally, an increasing number of households in an area reflects an increasing demand for dwellings which leads to higher house prices unless there is a sufficient supply of new dwellings to satisfy demand. The dwelling figures are indicative of average size dwellings. When the number of households is less than the number of dwellings this indicates larger sized dwellings. If there are a larger number of households it indicates smaller sized dwellings (e.g. flats). Table 2.7 shows that the highest growth is expected in the unemployed/inactive group due to the increasing size of the retired population, particularly in the City and South Cambs. It can be observed that the professional and managerial (SEG1) and administrative and clerical groups (SEG2) are predominantly in the City and South Cambs - these are the groups, amongst working households, that will grow most in the Sub-region .

This household growth is the product of increased jobs in and around the city and the provision of new dwellings. Unfortunately, the demand for housing in these areas is greater than the supply of dwellings, allowed by the Structure Plan, leading to an increase in dwelling rents and prices, which in turn will affect the cost of living. In addition to housing cost, the cost of living includes transportation and other goods and service costs. The increase in transport costs is due to rising congestion. Figure 2.5 illustrates the monthly costs for the average household. The most dramatic effect is in the City, where the monthly cost of living increases by 73% between 2001 and 2016. The average cost of living rises by 42% for the Sub-region.

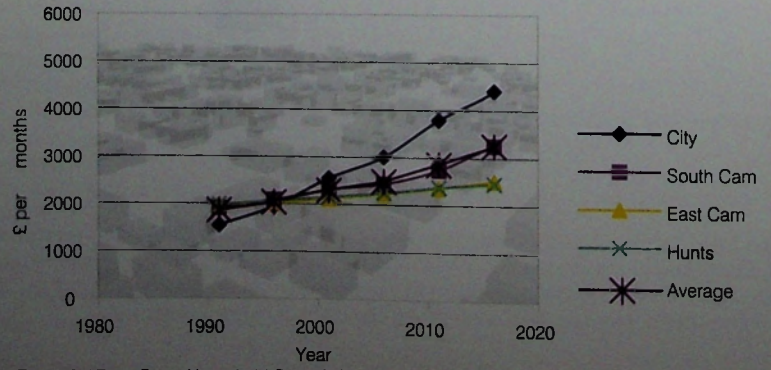


Figure 2.5 Base Case: Household Cost of Living- £ / month

	2001		2006		2011		2016	
Camb. City	49	(100)	52	(106)	58	(119)	66	(134)
South Cambs	55	(100)	58	(106)	64	(118)	71	(130)
East Cambs	27	(100)	27	(103)	27	(101)	28	(104)
Hunts.	62	(100)	64	(103)	66	(106)	68	(109)
Total	193	(100)	201	(105)	215	(112)	233	(120)

Table 2.3 Base Case: Location of Households x 1000 (2001 = 100)

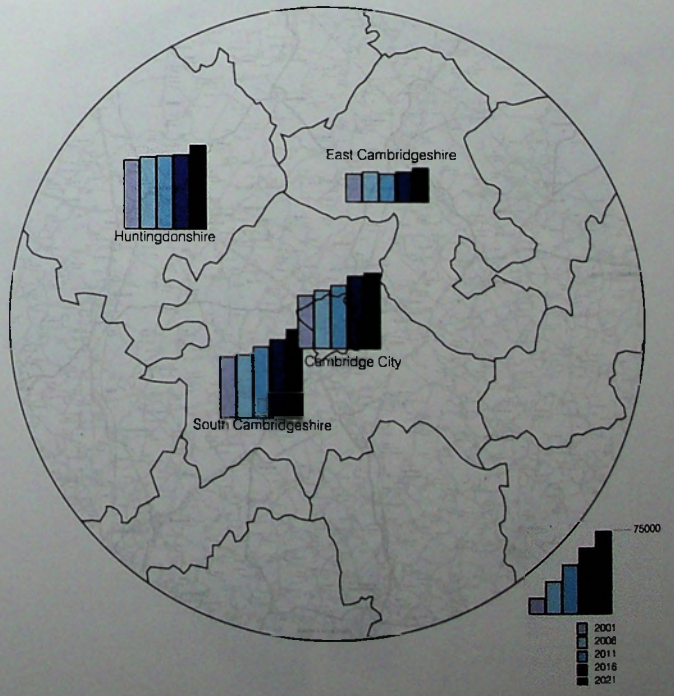


Figure 2.6 Base Case: Location of Households

Although the cost increase will impact negatively in the Sub-region, it is substantially less than the predicted increase given by Cambridge Futures (1999)[23] of 78% (4% per annum) if no further development in or around the City was allowed. In other words, the forecasted increase of the cost of living of over 2% per annum, represents an improvement in relation to the current situation where little development has been allowed in the area and thus costs are increasing at a much faster rate.

Figure 2.8 illustrates the average household cost of living in map form and table 2.4 gives the actual numbers.

	2001		2006		2011		2016	
Camb. City	2551	(100)	3008	(118)	3791	(149)	4407	(173)
South Cambs	2310	(100)	2440	(106)	2740	(119)	3258	(141)
East Cambs	2116	(100)	2240	(106)	2365	(112)	2519	(119)
Hunts.	2155	(100)	2249	(104)	2376	(110)	2459	(114)
Average	2292	(100)	2493	(109)	2856	(125)	3251	(142)

Table 2.4 Base Case: Household cost of living - £ / month (2001 = 100)

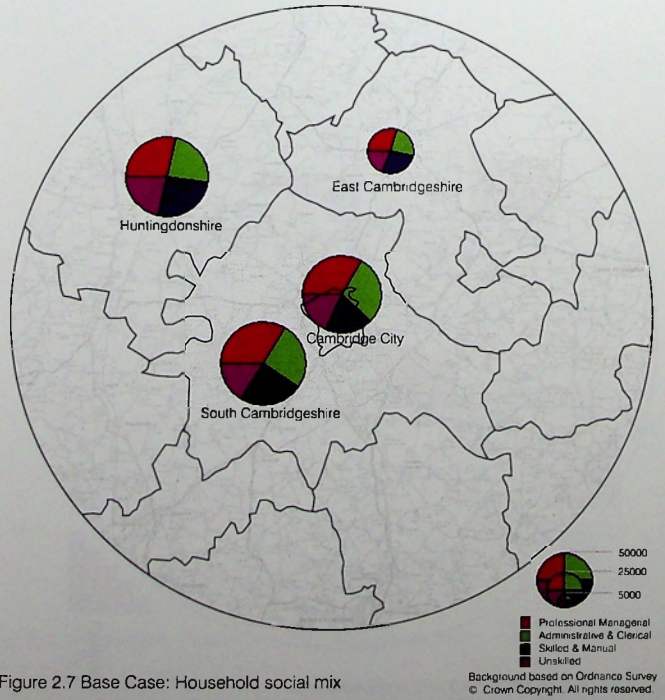


Figure 2.7 Base Case: Household social mix

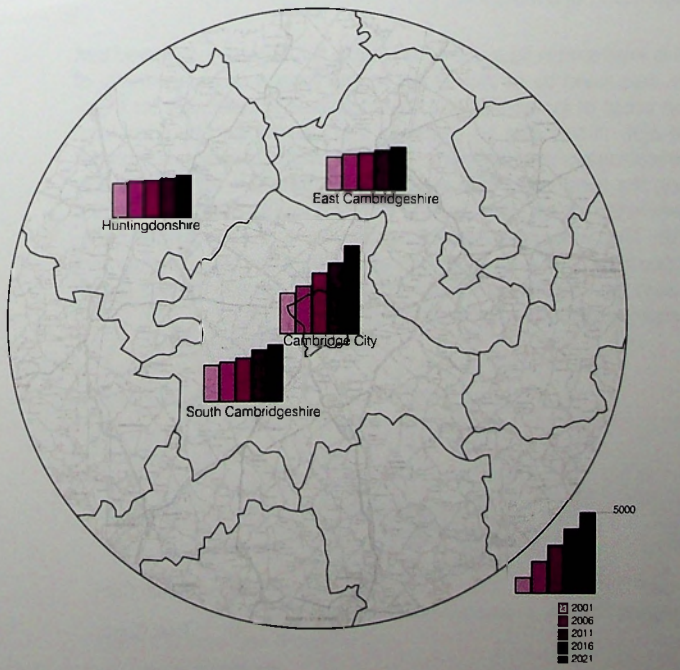


Figure 2.8 Base Case: Household cost of living

	SEG 1				SEG 2				SEG 3				SEG 4				Inactive & UnEmp				Total			
	2001		2016		2001		2016		2001		2016		2001		2016		2001		2016		2001		2016	
Camb. City	12	(100)	15	(128)	10	(100)	13	(130)	7	(100)	8	(123)	7	(100)	8	(128)	14	(100)	21	(148)	49	(100)	66	(134)
South Cambs	14	(100)	18	(128)	11	(100)	14	(128)	11	(100)	12	(117)	7	(100)	9	(124)	13	(100)	19	(147)	55	(100)	71	(130)
East Cambs	6	(100)	5	(95)	4	(100)	4	(96)	5	(100)	5	(95)	4	(100)	3	(96)	8	(100)	10	(125)	27	(100)	28	(104)
Hunts.	14	(100)	14	(101)	11	(100)	12	(104)	12	(100)	13	(103)	10	(100)	11	(105)	14	(100)	19	(129)	62	(100)	68	(109)
Total	45	(100)	52	(116)	36	(100)	42	(117)	35	(100)	38	(110)	28	(100)	31	(114)	49	(100)	69	(138)	193	(100)	233	(120)

Table 2.4 Base Case: Households by Socio Economic Group x1000 (2001 = 100)

2.3 Location of employment and cost of production

Figure 2.10 and table 2.5 show that the model forecasts 24,000 more jobs in the City (+28%) and 15,000 more jobs in South Cambs (+26%). These increases are the product of growth in the City and surrounding area of retail, private services and the tertiary sector of the economy (i.e. higher education, research and development and associated services). (See figure 2.11 and table 2.6.)

The cost of production is illustrated in figures 2.12 and table 2.7. It can be observed that the cost of production, calculated by employee per month (based on salary, rental of premises and transport costs of inputs and outputs) increases substantially for Cambridge City (see figure 2.9). It can also be observed that Cambridge City goes from being the most economical location for employment (thus attracting the highest number of businesses) to being the most expensive by 2016 (and therefore would probably not attract further growth in the future). The average increase for the Sub-region is 29% between 2001 and 2016. This, while not a positive contribution to the Cambridge economy, is about half that predicted by Cambridge Futures (1999), if no more development was allowed in and around the City. The productivity of the work force in the Sub region would require a 1.5% improvement per annum to remain competitive.

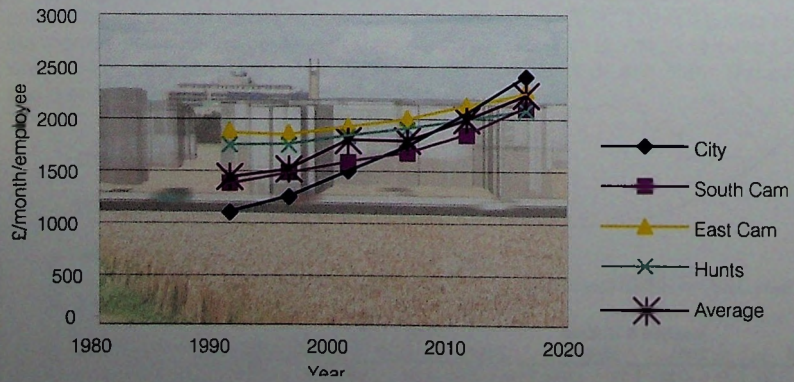


Figure 2.9 Base Case: Cost of production - £ / month/ employee

	2001		2006		2011		2016	
Camb. City	85	(100)	90	(106)	100	(117)	109	(128)
South Cambs	57	(100)	62	(110)	68	(120)	72	(126)
East Cambs	23	(100)	24	(104)	23	(102)	23	(103)
Hunts.	69	(100)	73	(106)	74	(106)	76	(110)
Total	234	(100)	249	(107)	265	(113)	280	(120)

Table 2.5 Base Case: Location of employment x 1000 (2001 = 100)

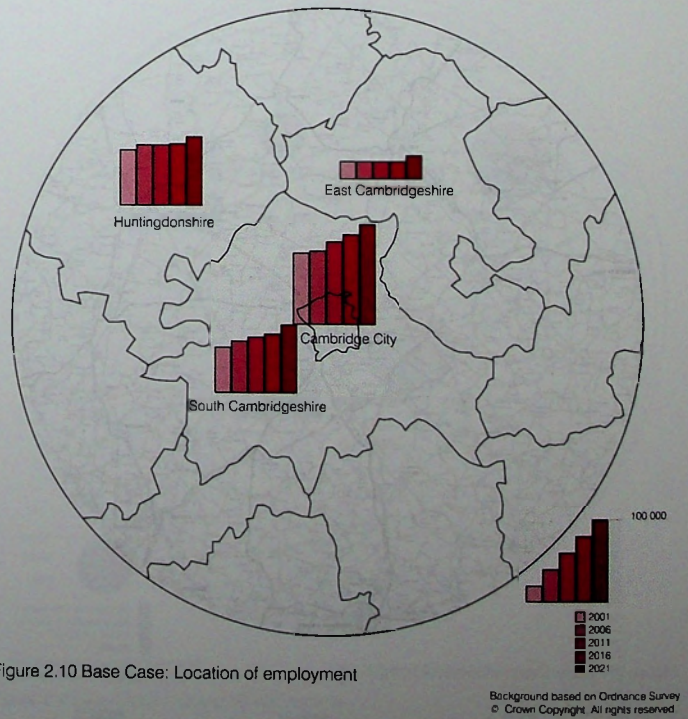


Figure 2.10 Base Case: Location of employment

	2001		2006		2011		2016	
Camb. City	1504	(100)	1733	(115)	2065	(137)	2406	(160)
South Cambs	1587	(100)	1674	(105)	1848	(116)	2098	(132)
East Cambs	1939	(100)	2014	(104)	2135	(110)	2279	(118)
Hunts.	1837	(100)	1900	(103)	1983	(108)	2086	(114)
Average	1717	(100)	1830	(107)	2008	(117)	2217	(129)

Table 2.7 Base Case: Production cost - £ / month / employee (2001 = 100)

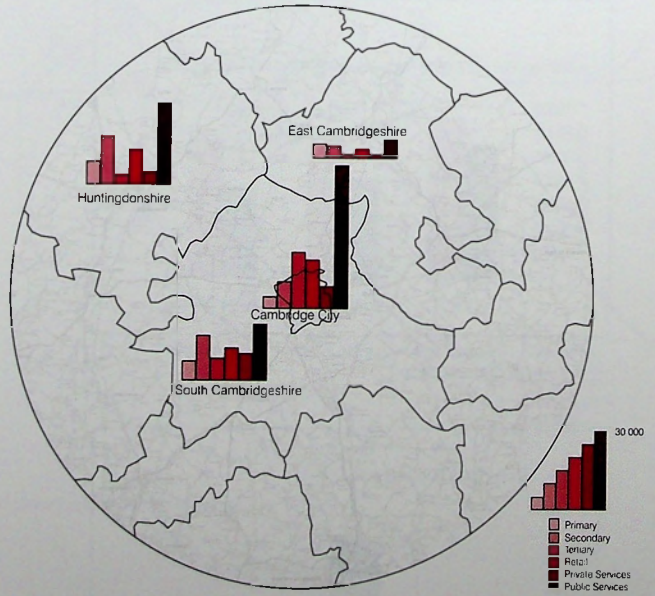


Figure 2.11 Base Case: Location of employment by type - 2016

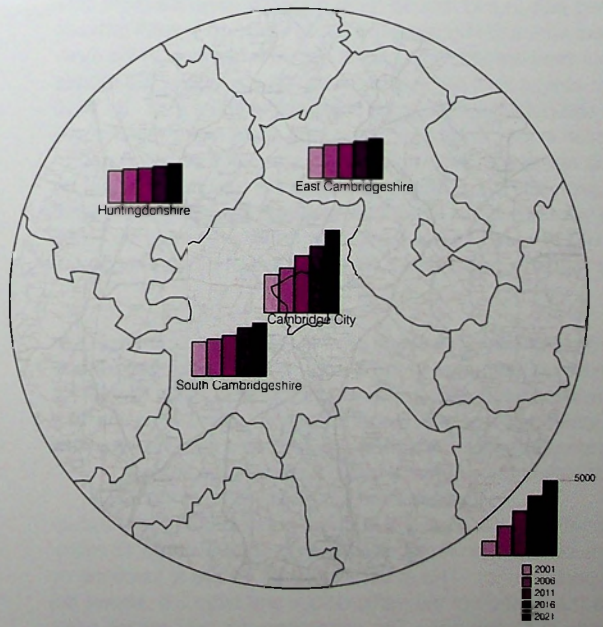


Figure 2.12 Base Case: Production cost

	Primary				Secondary				Tertiary				Retail				Private Services				Public Services				Total			
	2001		2016		2001		2016		2001		2016		2001		2016		2001		2016		2001		2016		2001		2016	
Camb. City	4	(100)	4	(103)	10	(100)	9	(96)	16	(100)	20	(130)	13	(100)	17	(131)	6	(100)	8	(139)	37	(100)	50	(134)	85	(100)	109	(128)
South Cambs	7	(100)	7	(104)	17	(100)	16	(94)	3	(100)	8	(249)	8	(100)	11	(138)	4	(100)	10	(228)	18	(100)	20	(112)	57	(100)	72	(126)
East Cambs	5	(100)	5	(104)	5	(100)	4	(94)	1	(100)	1	(120)	3	(100)	4	(130)	1	(100)	2	(119)	7	(100)	7	(96)	22	(100)	23	(103)
Hunts.	8	(100)	8	(105)	17	(100)	18	(103)	3	(100)	4	(121)	11	(100)	13	(118)	4	(100)	5	(127)	27	(100)	29	(109)	69	(100)	76	(110)
Total	24	(100)	25	(104)	48	(100)	47	(98)	23	(100)	33	(145)	35	(100)	45	(128)	15	(100)	24	(160)	89	(100)	106	(119)	234	(100)	280	(120)

Table 2.6 Base Case: Location of employment by type x 1000 (2001 = 100)

2.4 Transport impacts

The growth in households and jobs in and around Cambridge will generate more congestion. Locating houses near jobs and improving the public transport system reduces the proportion of car trips, but there are still more cars in absolute numbers in the existing streets. The percentage of trips into, within or from the City by aggregate modes of travel (i.e. car, cycle/walk and public transport) are illustrated in figure 2.13. By 2016 the model forecasts a reduction in the percentage of car trips and a higher percentage of public transport trips. This represents 50% more public transport trips compared to 2001, due to the introduction of HQPT and more bus use as the new development on the edge of the built up area favours bus use rather than walking. According to the 2016 Base Case, the proposed HQPT would attract 5,000 trips and there would be 6,000 extra bus trips in the 3 hour morning peak period. The numbers of trips by mode are illustrated in figure 2.14.

Car traffic volume (measured by km travelled) would grow by 18% overall. There would be more cars entering or leaving Cambridge in the 3 hour morning peak period, and more car trips by drivers travelling wholly within Cambridge. This is partly due to the population growth within Cambridge and the longer distances involved as the City expands making walking and cycling less attractive. Figure 2.15 shows how the new developments around the city affect the volume of traffic in percentage terms.

As a consequence of the growth in traffic there will be more congestion thereby reducing traffic to crawling speeds on the main roads within Cambridge (average 13 miles/hour in the 3 hour morning peak period). This in turn increases delays at junctions by 67%. Figure 2.16 illustrates the location of the traffic delays and table 2.8 shows the congestion on the main roads of Cambridge. The congestion not only wastes more time and energy in travelling, but also produces 31 % more carbon emissions.

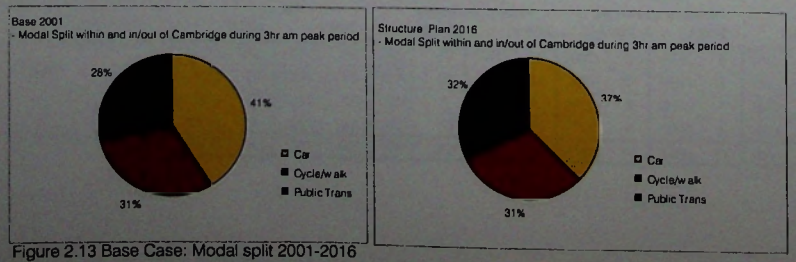


Figure 2.13 Base Case: Modal split 2001-2016

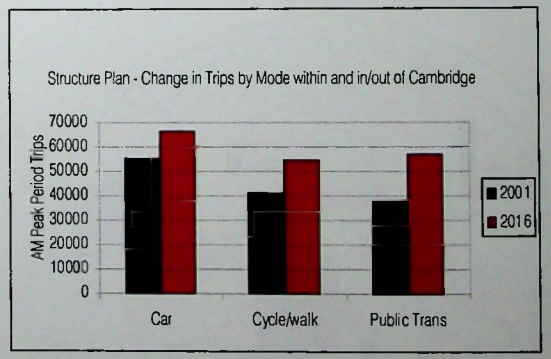


Figure 2.14 Base Case: Change in trips by mode within and in/out of Cambridge

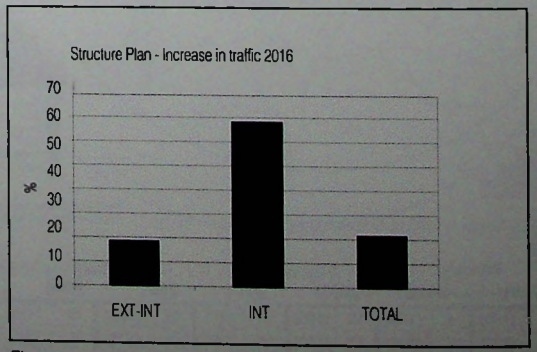


Figure 2.15 Base Case from 2001 to 2016: Percentage change in car traffic in Cambridge

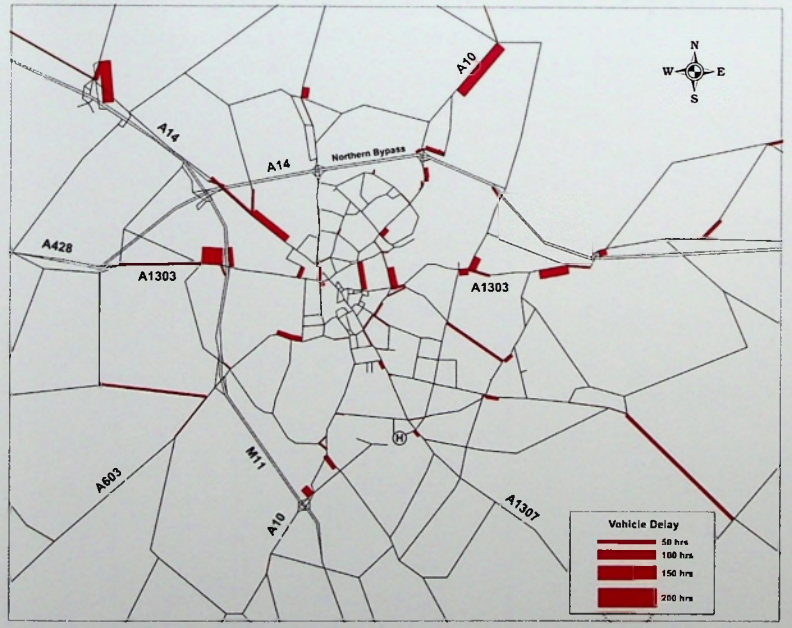


Figure 2.16 Base Case: Increase in delays

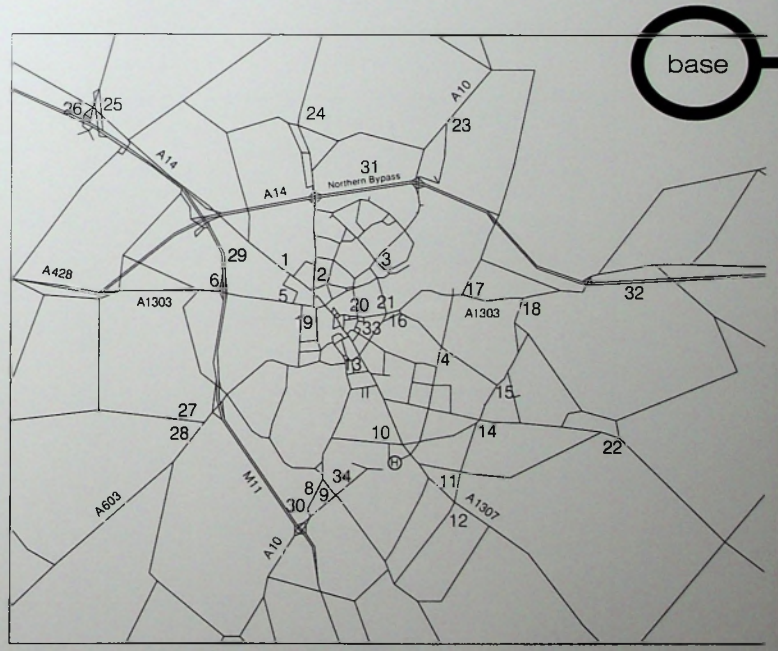


Figure 2.17 Base Case: Location of links for table 2.8

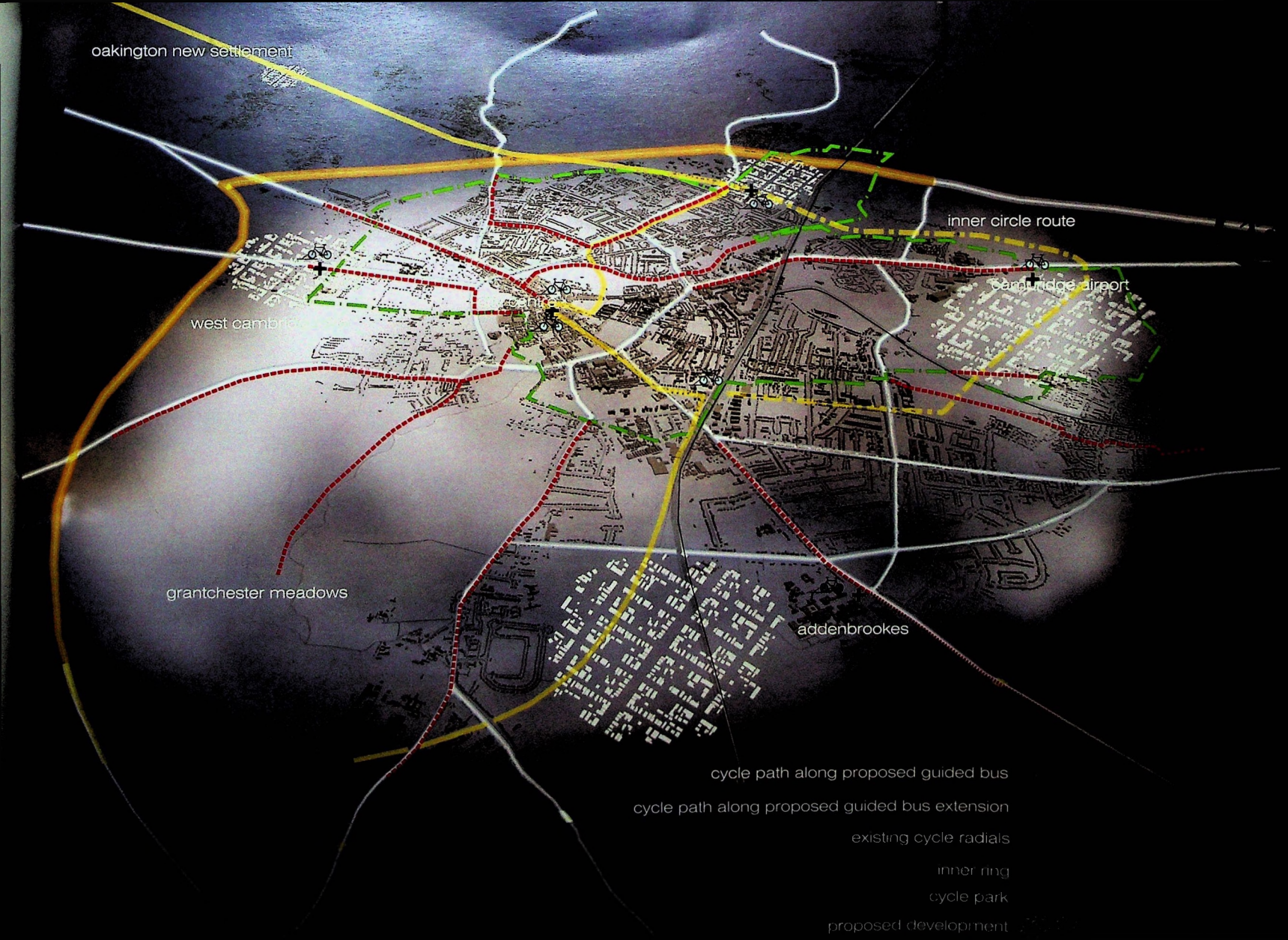
2.5 Sustainability Implications

The Structure Plan [24] supports the growth of the knowledge based economy of the Sub-region by providing more housing where the numbers of jobs are growing, improving the social balance, and protecting the high quality environment of the city. However, the growth in jobs and dwellings will present major challenges, because housing costs will continue to rise, with respect to 2001 values, as demand outstrips supply, resulting in higher costs of living and of production. It is important to recall that these increases are about half the expected increase if no further development was allowed within or around the built-up area of the city. Nevertheless, there is a risk to the economic prosperity of the Sub-region and its social development.

However, the most significant problem is the traffic implications, because whilst there is growth in public transport use in absolute and proportional terms, there will also be a substantial increase in car traffic in the city. This is a consequence of the rise in the number of higher income households relative to 2001 and the increase in distance from dwellings to jobs and other facilities as the city expands. The consequence is an increase in delays, with crawling speeds on the main city roads and a substantial increase in carbon emissions (+30%).

		Direction	Base 2001 Demand Flow(PCU/hr)	Delay (secs)	Demand Flow/ Capacity	Av Speed (kph)	Base Case 2016 Demand Flow (PCU/hr)	Delay (secs)	Demand Flow/ capacity	Av Speed (kph)
1	Huntingdon Rd	E'bd	1680	228	1.20	13	1647	228	1.18	13
2	Histon Rd	S'bd	952	80	0.76	2	995	67	0.80	2
3	Milton Rd	S'bd	890	219	0.81	4	994	278	0.97	3
4	Coldhams Lane (East of Barnwell Rd)	NW'bd	626	14	0.81	41	731	184	1.13	19
5	Madingley Rd east of M11 jcn 13	E'bd	1430	18	1.02	43	1394	14	1.00	46
6	Madingley Rd west of M11jcn 13	E'bd	1630	325	1.16	5	1731	454	1.24	4
7	Barton Rd through Newnham	E'bd	906	173	1.08	7	923	262	1.15	5
8	Hauxton Rd	NE'bd	1650	328	0.98	4	1157	141	0.73	8
9	Shelford Rd (adjoining Trumpington High St)	NW'bd	566	206	0.75	6	817	260	1.09	5
10	Long Rd	E'bd	615	6	0.31	53	379	6	0.23	53
11	Queen Edith's Way	W'bd	268	57	0.76	17	292	155	1.07	8
12	Babraham Rd, (nr Addenbrookes)	NW'bd	1052	72	1.02	9	917	168	1.07	4
13	Hills Rd (Nr Lensfield Rd)	NW'bd	514	115	0.72	11	563	123	0.78	11
14	Fulbourne Rd (Nr Cherry Hinton High St)	W'bd	1065	15	0.72	29	1374	121	1.05	8
15	Cherry Hinton Rd (Church End, Cherry Hinton)	SW'bd	962	33	1.00	18	996	177	1.07	5
16	Newmarket Rd (adjoining East Rd)	W'bd	1382	39	1.02	19	1358	95	1.09	10
17	Ditton Lane	SW'bd	1002	302	1.15	4	1028	347	1.18	4
18	Newmarket Rd (East of Airport Way)	W'bd	1430	281	1.14	11	1438	292	1.15	11
19	Queen's Rd	S'bd	1695	3	0.85	43	1900	4	0.96	43
20	Victoria Avenue	S'bd	1400	106	1.13	16	1486	187	1.20	11
21	Elizabeth Way	S'bd	1949	21	1.10	30	1941	192	1.23	8
22	Balsham Rd (approaching Fulbourne)	NW'bd	985	95	1.03	43	1016	152	1.06	35
23	A10 Ely Rd (approaching Milton)	SW'bd	1589	273	1.13	20	1614	305	1.15	18
24	B1049 Cottenham Rd (approaching Histon)	S'bd	230	708	1.34	1	1226	274	1.12	1
25	B1050 Hatton's Rd (jcn with A14)	S'bd	1190	30	0.67	59	2274	38	0.66	58
26	A14 (West of Bar Hill jcn)	SE'bd	3712	28	0.89	79	2961	4	0.55	113
27	New Rd, Barton	E'bd	967	47	1.01	54	1002	113	1.04	39
28	A603 Cambridge Rd	NE'bd	1393	15	1.00	63	1418	38	1.01	44
29	M11 jcn 14 to jcn 13	SE'bd	1814	0	0.43	115	2883	1	0.69	110
30	M11 jcn 12 to jcn 11	SE'bd	2225	3	0.54	112	3000	8	0.72	107
31	A14 Histon to Milton	E'bd	2653	4	0.65	97	3732	7	0.60	92
32	A14 approaching Newmarket Rd jcn	W'bd	2072	2	0.52	101	2623	7	0.66	99
33	East Road	S'bd	788	136	0.98	8	845	154	1.07	7
34	Proposed Addenbrookes Link	E'bd	N/A				1700			

Table 2.8 Base Case: Characteristics of selected links in the highway network 2001- 2016, see Appendix B Table B1 for notes.
N.B. Average speeds are taken from the road link closest to the junction, hence, average speed may be lower than further up-stream from the junction.


oakington new settlement
inner circle route
Cambridge airport
west cambrid
grantchester meadows
addenbrookes
cycle path along proposed guided bus
cycle path along proposed guided bus extension
existing cycle radials
inner ring
cycle park
proposed development

3. Cycling and Walking Option

3.1 Introduction

Nationally the percentage of trips made by cycling account for less than 2% [25]. In the Cambridge Sub-region this is much higher, accounting for 15% of all trips. This is partly because of favourable topographical conditions (i.e. flat terrain) but also partly because the City of Cambridge has according to Sustrans [26] 'positive local culture that encourages cycling regardless of social status'. Currently cycling within the City accounts for 25% of trips and walking accounts for 24%. These figures make Cambridge a rather special place that is only surpassed in the proportion of cyclists by some Dutch and Danish cities that also have flat topographies.

As the length of the average cycling trip increases, the proportion of people cycling reduces. Nationally, the average length of trips has gone up by 30% in the last 20 years, with a 50% decline in the use of bicycles[27]. Within the City of Cambridge, the use of bicycles has remained unchanged.

According to Sustrans [28] 'A number of factors are likely to have played a part including:

- The compact nature of the city, which has not changed greatly over recent decades.
- The absence of major roads around the city centre; these now form barriers for cyclists in many other cities.
- The high resident population in the city centre, contrary to many cities, where people have moved away from the city centres.
- The lack of growth of motorised traffic within the city over recent years, which is contrary to national trends.
- The positive local culture that encourages cycling regardless of social status. This is not the case in, for instance, the Fenland towns, where a car is seen as a symbol of success.
- The difficulties faced by car drivers in Cambridge, which makes the car a less attractive option for many than a bicycle. This is not yet the case in many other cities.
- Improvements to the cycle infrastructure within the city.
- The existence of a number of important 'green' routes through the city, which have maintained their attractiveness despite worsening conditions on the roads.

Figure 3.1 Cycling & Walking Option: Cycleways along an extension to the proposed guided bus could weave Cambridge Airport in to the existing cycle network.

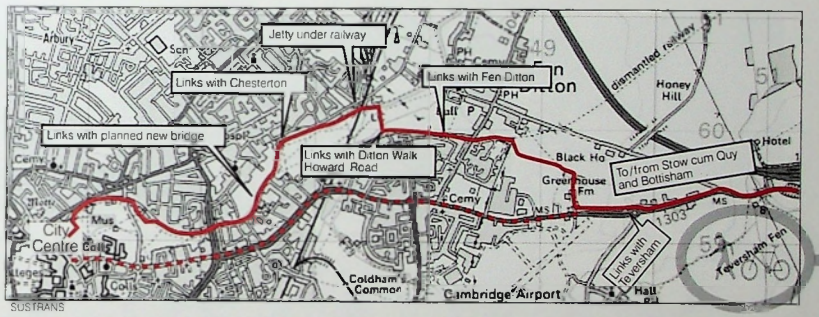
- The success of a number of softer measure such as the Travel for Work Partnership.'

Failure to maintain the current percentage of cycling trips would mean more congestion in the roads. The 2016 Base Case suggests that there would probably be a 60% increase in the volume (vehicle km) of car traffic within the City by 2016. This is partly due to an approximate 30% increase in numbers of trips and partly due to the increased length of travel from the edge locations where the bulk of the additional population will be located. The 2016 Base Case assumes that the attractiveness of cycling and walking compared to other modes remains the same as at present. To achieve this the new developments need to provide attractive facilities for cycling and walking. However, as the City expands, the average distance to central facilities will increase and this will tend to diminish the percentage of trips made by cycling. To counteract this tendency there needs to be a continuing improvement of the cycling and walking network on the main travel lines. See figure 3.4

3.2. Description

It is important to extend the current cycle and pedestrian ways to the new development areas and create new ones to improve the connectivity of Cambridge. If necessary the use of statutory powers should be considered to acquire the land needed to deliver

Figure 3.2 Cycling & Walking Option: A reworking of the bus station provides the opportunity to open up the pivotal point in the pedestrian connection between the City Centre and Grafton



Jubilee Cycle Route/National Cycle Network Route 51

On road alternative to Jubilee Cycle Route, serves slightly different places, but with numerous junctions. Journey times are similar

Figure 3.3 Cycling & Walking Option: Jubilee Cycle Route

this extended network. Ideally, however, this would be achieved by consensus and a partnership appraisal. The following is summarised by Sustrans[29]:

' A Green Cycle Route Plan for Cambridge is already emerging through the interest of a partnership that has evolved from those involved with the Jubilee Cycle Route and including:

- Cambridgeshire County Council
- Cambridge City Council
- South Cambridgeshire District Council
- Cambridge Cycle Campaign
- CTC
- National Trust
- RSPB
- Sustrans
- Marshall of Cambridge

The emerging plan includes the main potential corridors in the City within a tightly drawn City ring with separate links to the countryside and visitor attractions. The fact that the network involves a combination of local authority land, private land and development opportunity areas and passes through both Cambridge City and South Cambridgeshire means that a partnership approach is particularly useful if the network is to be progressed. All the proposals are achievable, subject to funding and various agreements. It is believed that the chances of attracting funding and using the network as a means to encourage an increase in cycling are greater if the network is treated slightly differently to the city-wide network, which is seen as much more of a highways matter.

For the Cambridge Green Cycle Network to be a success it needs to be sensitive to its surroundings and be built to a good standard, in terms of the quality of the paths and the attractiveness of the routes. The Network also needs to be convenient, easily accessible and integrated with cycle routes all around the City. It is not a question of developing either the Green network or the road network, but a question of doing both, if cycling is to flourish in Cambridge. In Copenhagen, a plan gives a definition of Green Cycle Routes, which needs to be applied to Cambridge.

" Green Cycle Routes ...are intended as a new option for cyclists, particularly those who have a long way to go... Cycle routes are built to a high standard... and are designed to minimalize the stops cyclists have to make because of other traffic. In addition to serving as home-workplace routes they are also intended to have a recreational function. The green cycle routes are co-ordinated with the main cycle path network and the existing national routes will be adjusted to the green cycle routes as the occasion arises."

In the above context it is interesting to note that using the Jubilee Cycle Route from Fen Ditton to Cambridge City Centre involves no at-grade road crossings, whereas an on-road route would involve numerous crossings. On the other hand, the Jubilee Cycle

Figure 3.4 Cycling & Walking Option: Pedestrian and cycle route - shared use generally works well in Cambridge

Cambridgeshire County Council

Figure 3.5 Cycling & Walking Option: Proposed Green Cycle network (Sustrans 2003)

Route is unlit and may flood under exceptional circumstances, so is unlikely to be the best option for every journey.

Achieving the Green Network

Much of the proposed network for Cambridge is achievable within the next 5 years and this is indicated on the plans, assuming that the network is carefully integrated into development plans.

Some other routes are indicated as possibly taking longer than 5 years, such as the proposed routes following the main rail corridor. These involve the use of "spare" land besides the railway and "spare" arches at rail crossings. With the support of the rail industry and others the route is achievable to high standards, but rapid progress is unlikely at the moment. The route has become known locally as the "Chisholm Trail", in recognition of the part played by Jim Chisholm in proposing and promoting the route and it needs to be protected as a future route if it is to be achieved. New routes that should be achieved as part of developments foreseen in the structure plan are not shown in figure 3.5, but will need to be well integrated with the plan.

- Inner Circle Route
- Proposed guided bus extension
- Green Route - Largely existing, but may need major works to bring it up to standard
- Green Route - Not an official route at present. Requires works but achievable within five years.
- Green Route - Not an official route at present. Requires works and land, planning and funding issues may take more than five years.

In order to complete the first phase of the network, as envisaged on the plan, work is already underway identifying funding possibilities and the missing links. Given the potential for developer contributions it is likely that development will fund most of the work with an estimated £500,000 needed to complete the missing links.

The route around the City has been proposed as a Cambridge Green Wheel or Ring or Necklace with the name still undecided. However experience from the Peterborough Green Wheel, the Jubilee Cycle route and numerous other projects has shown the advantages of having a named route in terms of raising the profile of the route.

Looking beyond the City

If Cambridge were to significantly increase cycling and at the same time cycling were to decrease in the surrounding communities it would be hard to see this as a success, especially in the context of the National Cycling Strategy, which has set a target of quadrupling the level of cycling by 2012 compared to 1996 levels. These targets are proving difficult to meet and Counties such as Cambridgeshire, which are considered to have good potential for increasing cycling are likely to be more and more in the National spotlight. It is therefore vital that not only is cycling increased in Cambridge, but that this is extended to the surrounding communities. For instance the proposed new settlement at Longstanton/Oakington should therefore be aiming to achieve Cambridge type levels of cycling rather than settle for average UK levels. The success of the Kesgrave development [30] near Ipswich shows that this can be achieved, with approximately 75% of pupils at Kesgrave High School arriving by bicycle. This has been achieved through a combination of:

- Good cycle routes
- Supportive schools, which provide good cycle parking and lockers.
- Difficult conditions for drivers, whereby driving to school is much harder than cycling or walking.

The rural areas around Cambridge present in many ways a greater challenge than the city itself, given that cyclists have little choice about the routes they take and that rural traffic is growing at a much higher rate than urban traffic. However given that most trips are local ones and many of the longer distance trips are likely to be focused on Cambridge there is good potential for increasing cycling. See figure 3.6

Focusing on improving links between the necklace villages and Cambridge has the added advantage of having benefits for Cambridge residents. This is an area that the National Trust, RSPB and Countryside Agency have picked up in their "Widen the Choice" Rural Transport Partnership.' [31]

Figure 3.6 Cycling & Walking Option: Proposed Green Network for the Cambridge area (Sustrans 2003)

3.3 Assessment

The proposed improvements for cycling and walking, such as those described above by Sustrans, have not been modelled separately because the strategic nature of the model is not sensitive enough to local changes. Distance and time for cycling and walking are not fundamentally changed by the improvements. The proposed improvements probably do alter the convenience of the routes and also their safety, making cycling and walking more attractive. Therefore the improvements may counteract the probable decline of cycling as average distances become larger.

What has been modelled is the impact on cycling and walking after introducing the other options. As it can be observed in table 3.1 the Public Transport and Orbital Options reduce cycling trips by 7% within Cambridge while the congestion charging option increases them by 13%. The Combined Option maintains practically the same level of cycling trips.

The improvements in public transport also reduce the walking trips by 6%, while there are 2% fewer with the Orbital Option. The Congestion Charging Option increases walking trips by 11% while the Combined Option maintains practically the same number of walking trips.

The impact on cycling and walking is due more to the changes in the number of working households living within Cambridge City rather than the policies themselves. The exception is the Public Transport Option, which would offer a convenient alternative to walking in the City.

The cost of implementing the proposed cycle network has been estimated at about £1.3 million. The inner circle is estimated at about £0.8 million and the extension of radial routes at about £0.5 million. In addition, there are costs in building bridges over the Cam and A14 but these are funded separately from developers' contributions.

	Base		Public Transport		Orbital		Congestion Charging		Combined	
	trips	Base	change	Base	change	Base	change	Base	change	Base
Cycling	24,300	(100)	-1,630	(93)	-1260	(95)	3080	(113)	-230	(99)
Walking	20,220	(100)	-1,340	(93)	-540	(97)	2540	(113)	260	(101)

Table 3.1 Cycling & Walking Option: impact on cycling and walking after introducing each option compared with the Base (2016 = 100) for a morning 3hr peak period

Figure 3.7 Cycling & Walking Option: Pedestrianised market square (cycling permitted outside peak shopping hours)

Figure 3.8 Cycling & Walking Option: Parking of bikes can be a problem in Cambridge

Figure 3.9 Cycling & Walking Option: More cycle lockups could be provided at transport interchanges


oakington new settlement
new chesterton station
west cambridge
city centre
cambridge airport
grantchester meadows
addenbrookes hospital
railway line
guided bus
extension to guided bus
existing park & ride
proposed development

4 Public Transport Option

4.1 Description

Extensive improvements to the public transport network have been tested (see figure 4.1) as a possible means of coping with the increase in travel demand and congestion that will be generated by the Structure Plan policies. The option tested included:

• Four new Park and ride sites on radial routes: Histon Road, Cambridge Road (Cherry Hinton), Barton Road and Caxton Gibbett (A428). The Histon Road site would be served by the Huntingdon to Cambridge guided bus system (part of the Base Case). There would be a conventional park and ride bus service between the Barton Road and Cherry Hinton sites. The Caxton Gibbett site would be an extension to the west of the existing service between the Newmarket Road and Madingley Road sites.

• Expanding the HQPT, (high quality public transport), network to serve the new settlements at Bar Hill (A14) and Cambourne (A428), Fulbourn and the airport area development. It also includes an Orbital route around two thirds of the city linking all the edge employment sites from West Cambridge, serving the new housing development areas at the University Farm, NIAB and the Northern Fringe, the Technical College, Science Park, Innovation Centre, New Chesterton Sidings Station, crossing the River Cam near to the existing railway bridge, passing through the east of Fen Ditton, the proposed developments of the new airport and north of Cherry Hinton, Peterhouse Business Park, Addenbrookes Hospital, the proposed housing south and west of Addenbrookes, ending at the Trumpington park and ride site. The orbital route links all park and ride sites with the exception of the proposed Barton Road site. A full orbital link between Madingley Road and Trumpington Road was not tested because this area has no new significant development in the Structure Plan, and drivers can use the M11 as a distributor to the appropriate park and ride site west of Cambridge.

• Two tunnels under the city centre to improve the service levels of the high quality public transport and reduce bus congestion in the city centre arising from the forecast increase in public transport and the expansion of HQPT routes. One tunnel (2.7 Km) would serve the public transport routes travelling on a north-south axis and the other (3.3 Km) would serve the east -west movements. An entrance to the north-south tunnel could be constructed on Butt Green, adjacent to Victoria Avenue, as illustrated in figure 4.3. There could be a new underground bus station, as illustrated in figure 4.5, under the existing bus station and a redevelopment of the Bradwell Court shopping arcade. The tunnel would continue to another underground bus station at the railway station. The southern end of the tunnel would branch and emerge at two locations (figure 4.6); one linking to the guided bus system along the disused Bedford railway link and the other to the east of the railway, connecting to Davy Road and then at surface level to the Airport area and the orbital.

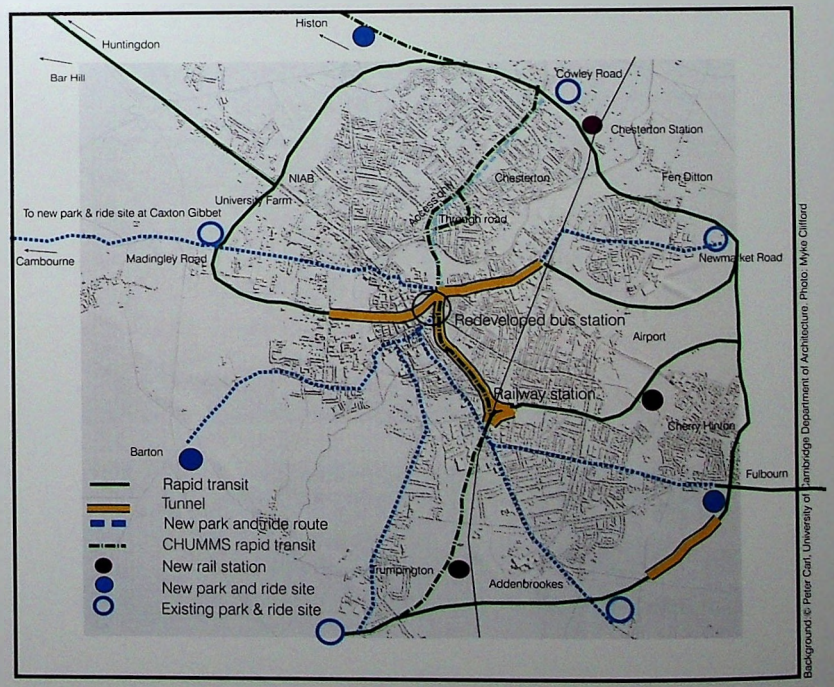


Figure 4.1 Public Transport Option: Extended network

The tunnel on the east-west axis would enter from the west (somewhere near Adams Road) then proceed under 'The Backs' and the Market Square, and an interchange with the north-south tunnel at the new underground bus station, and then continuing under Maids Causeway and along Newmarket Road to the airport site. The east-west tunnel would facilitate a high speed route through the city between the Madingley Road and Newmarket Road park and ride sites. The north-south tunnel would provide a high speed route through the city centre for the proposed Huntingdon to Trumpington HQPT scheme, also connecting the Cowley Road and Trumpington park and ride sites. In addition to the underground stations at the bus and railway stations there would also be underground stations at Parker's Piece, Market Square, the Grafton Centre and Coldham's Lane.

Wherever possible the tunnels would follow existing roads or open ground so that they can be constructed by cut and cover methods. Cut and cover in existing streets involves digging a trench along the road and then constructing a structural slab to form the roof of the tunnel. This part of the road can then be reinstated and a parallel trench dug to progressively widen the roof slab whilst keeping part of the road open. The road can then be fully reopened whilst the full depth of the tunnel is being excavated and constructed underneath. This is usually considerably cheaper than using a tunnelling machine, although this depends on the cost and feasibility of disrupting traffic and moving utility services. The tunnel system would allow appropriate vehicles (e.g. semi automatic hybrid diesel/electric buses) to travel uninterrupted in both directions under the medieval City Centre for most of the routes serving the edge-city locations, city centre and Railway Station.

• New rail stations have been tested at Cherry Hinton on the Newmarket line and near Addenbrookes Hospital on the line servicing local stations south of Cambridge near Addenbrookes Hospital. Both of these stations would be connected to HQPT serving nearby developments. The existing rail station could be improved by constructing new platforms to the East of the main railway lines, as illustrated in figure 4.6.

The Public Transport Option assumes a high degree of segregation between HQPT and other traffic to achieve an unimpeded and high frequency service, by the combination of the two tunnels, and segregated surface routes through proposed development sites, along disused railway tracks, and generally uncongested routes. Milton Road is the only significant exception, and a combination of measures would be required to achieve the high levels of service simulated in the model. These may include:

• A loss of verge width to allow segregation of the HQPT from other traffic.
• Making the section between Elizabeth Way and Victoria Road public transport and access only, with through traffic diverted around Elizabeth Way/Chesterton Road.
• Partial demolition of the terrace on the traffic island at Mitcham's Corner to allow HQPT junction priority when crossing between Milton Road and Victoria Avenue.

The simulation runs of the model until 2016 showed that despite an increase in the number or passengers using public transport some parts of the tested network were so under utilized (see Appendix B) that it was not worth including them in the appraisal. The most noticeable of these is the east-west tunnel which only achieved a modest increase in overall public transport patronage, above what is already achieved by park and ride on the Madingley Road-Newmarket Road corridor. Parts of the 'orbital' public transport route were also little used - the only exception being moderate use of the section between

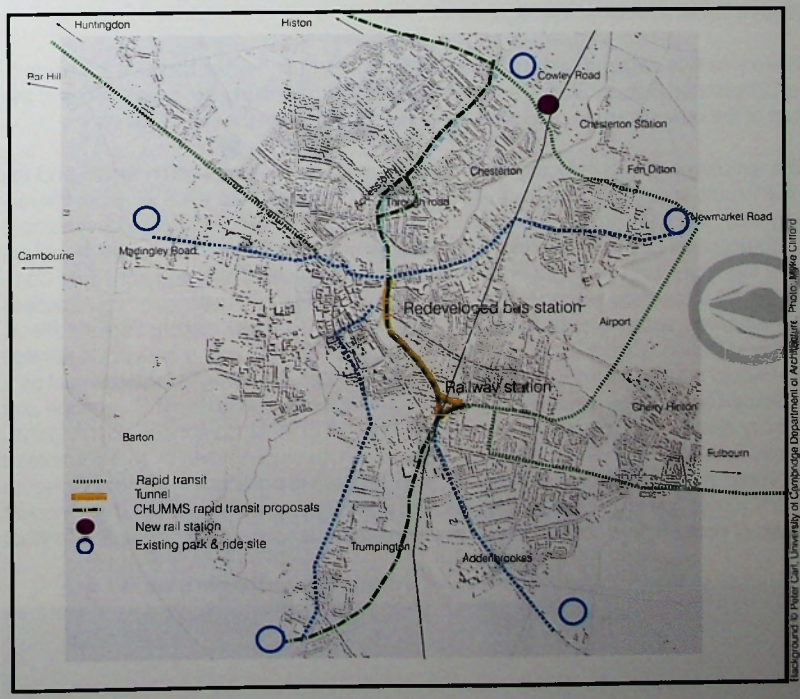


Figure 4.2 Public Transport Option: Optimized alternative

the proposed Chesterton rail station and the airport site. Other tested elements that did not attract sufficient patronage include the park and ride sites at Barton Road, Caxton Gibbett and Cambridge Road (Fulbourn) and the railway stations at Addenbrookes and Cherry Hinton. However, the simulation model did not include a detailed representation of the rail network outside the Cambridge areas and further study would be required to reach a definite conclusion about the feasibility of new rail stations, beyond that already committed for Chesterton. It is not possible to reach a definite conclusion about the viability of the park and ride on Barton Road because some of its potential patronage was probably attracted to the Madingley Road site due to the high level of service provided by the east-west tunnel. (The option would need to be re-run without the east-west tunnel to reach a conclusion.)

The north-south tunnel could be used by the proposed guided bus system, and would thus avoid the delays on the roads around the City centre, especially in the bus station area that is already saturated, and in the St. Andrews-Regents Street-Hills Road axis. The proposed tunnel would allow an extension of the pedestrian zone to St. Andrew's-Regent Street as illustrated in figure 4.4.

There was little demand for bus travel on the orbital route, except between the committed Chesterton Railway Station and the new development site at the airport. So only this part of the orbital route is proposed for the bus option until the year 2016

The simulation model forecasts a high level of use of the north-south tunnel and the HQPT route linking the City centre to the east of Cambridge via a tunnel under the railway line. The HQPT route from Fulbourn to the City centre attracted a modest number of potential users and are worthy of further appraisal. The north-south tunnel would act as a funnel through which all HQPT routes on a north-south axis and from east Cambridge could pass quickly under the city centre, (Figure 4.2). Passengers would access the tunnelled sections at underground stations at the railway station, Parker's Piece, and bus station. Figure 4.2 shows that West Cambridge is the only area of Cambridge that would not benefit from the proposed HQPT tunnel. The river and colleges act as a physical barrier that impedes public transport services between West Cambridge and the city centre. To facilitate the further development of West Cambridge beyond 2016, it may be worth considering the possibilities of a micro-tunnel used by fully automated vehicles. A micro-tunnel would cost substantially less to construct than the north-south HQPT tunnel due to its smaller diameter and would be appropriate for the more modest levels of patronage expected on the west axis. It could connect the bus station to West Cambridge with underground stations in the Market Square, and in the Queen's Road area. This proposal could be reviewed once the technology of fully automated micro vehicles has been more rigorously tested, (see www.atsltd.co.uk for an example currently being tested in the UK).

The north-south tunnel would carry about 1000 HQPT and park and ride passengers per hour (in each direction) in the peak periods, (equivalent to about 25 full single decker buses per hour in each direction). Local bus services could also be fitted with the appropriate technology to allow them to use the tunnel. This would greatly improve the city centre environment and release more street space for pedestrians and cyclists and would avoid the delays on the roads around the city centre especially in the already saturated bus station area, and on the St. Andrews-Regent Street-Hills Road axis. The proposed tunnel would allow an extension of the pedestrian zone to St. Andrew's-Regent Street.

The cost of the tunnel is substantial (up to £ 300 million), but the benefits to the city centre environment would be considerable. It would reduce travel times for passengers and reduce the costs of bus operators. In addition it would improve the accessibility of the city centre making it more attractive to shoppers and employers. It may, however, be possible to achieve a similar level of performance to a tunnel by allocating an exclusive (segregated) bus lane between the railway station and bus station. This would increase traffic congestion in the Hills Road/Lensfield Road area and bus congestion around the bus station, with adverse impacts on the city centre environment in terms of noise, pollution and safety. A detailed traffic management study would be required to assess whether the increase in public transport services could be accommodated through the city centre whilst also improving public transport journey times and reliability.

Figure 4.3 Public Transport Option: Possible entrance to a tunnel for public transport at Victoria Avenue

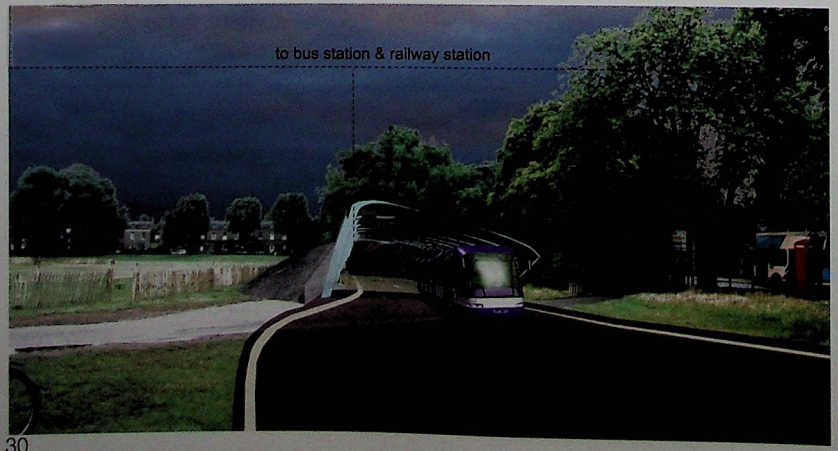


Figure 4.4 Public Transport Option: Regent Street as a pedestrian zone

4.2 Location of households and cost of living

Figure 4.7 and table 4.1 illustrate the predicted changes of households in relation to the base for 2016 and 2021. There is a reduction (2%) in the number of households living in the city. There is an increase in the South Cambs. district, as households take the opportunity offered by the public transport improvements to live outside in either relatively cheaper houses or in a higher standard of dwelling at the same cost. This increase in the supply of dwellings at accessible locations reduces the overall housing cost and the cost of living in relation to the Base Case in 2016, but still remains substantially higher than in 2001.

Figure 4.8 and table 4.2 show that the cost of living for the Sub-region would be 4% lower overall, with a greater reduction in the City (8%).

	SEG1		SEG 2		SEG 3		SEG 4		Inact & Unemp		Total	
Camb. City	-228	(98)	-227	(98)	-147	(98)	-90	(99)	120	(101)	-571	(98)
South Cambs	193	(101)	146	(101)	95	(101)	93	(101)	93	(100)	620	(101)
East Cambs	200	(104)	194	(105)	118	(102)	73	(102)	-16	(100)	569	(102)
Hunts.	-21	(100)	-28	(100)	-14	(100)	-15	(100)	-197	(99)	-276	(100)
Total	145	(100)	85	(100)	53	(100)	60	(100)	0	(100)	342	(100)

Table 4.1 Public Transport Option 2016: Change in location of households by SEG compared to the Base case (2016 = 100)

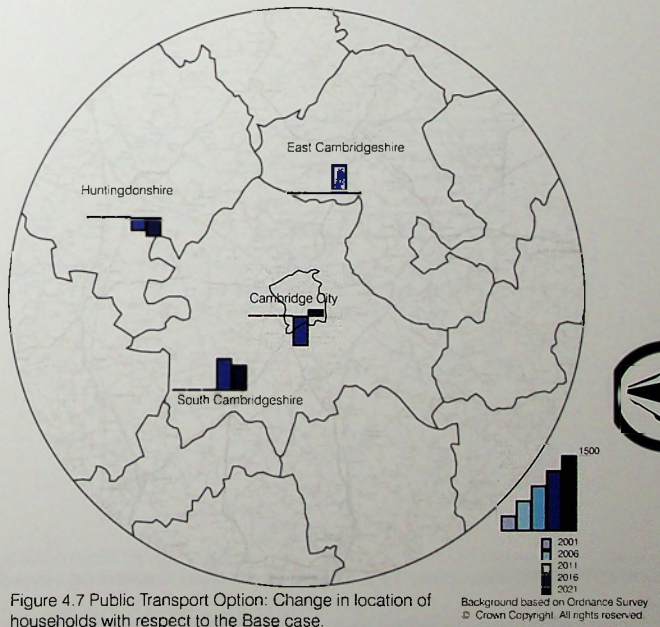
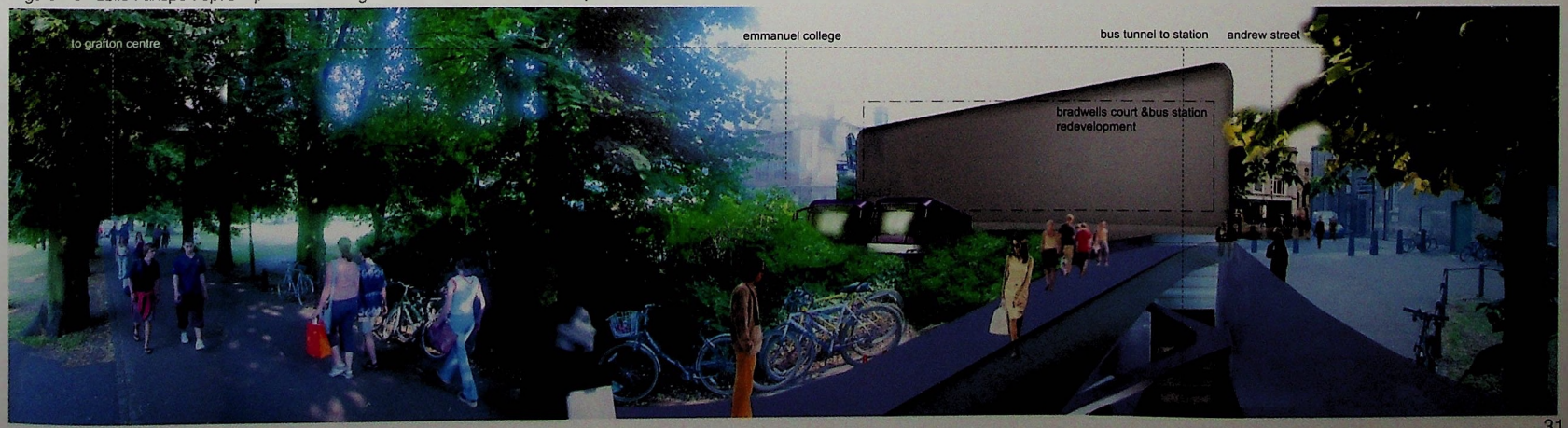


Figure 4.7 Public Transport Option: Change in location of households with respect to the Base case.

Figure 4.5 Public transport option: possible underground bus station and redevelopment of Bradwells Court



Camb. City	-372	(92)
South Cambs	-7	(100)
East Cambs	-25	(99)
Hunts.	-44	(98)
Average	-125	(96)

Table 4.2 Public Transport Option: Change in the cost of living compared to the Base case. £ / month (Base = 100)

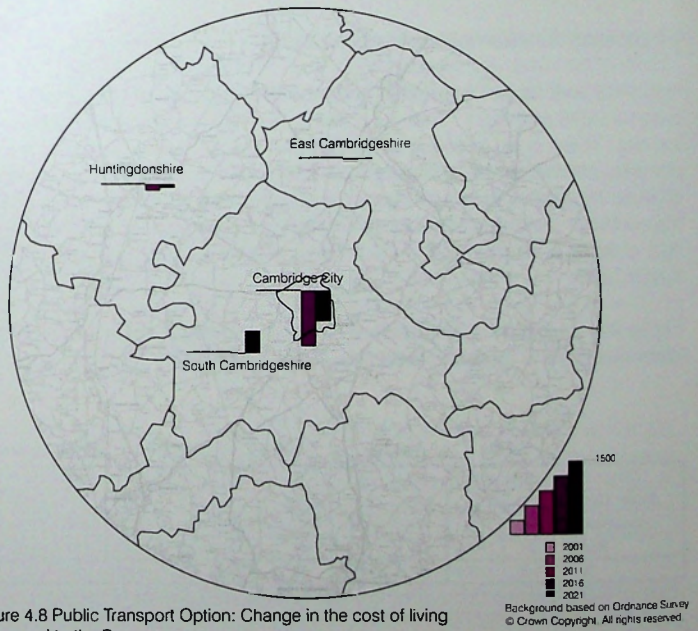


Figure 4.8 Public Transport Option: Change in the cost of living compared to the Base case.

Figure 4.6 Public Transport Option: Rail Station improvement (new platforms) and tunnels for guided bus

4.3 Employment location and cost of production

Figure 4.10 and table 4.3 illustrate the impact on the location of employment. In the year 2016 there is an increase in the number of jobs in the City in relation to the Base Case, resulting from the improvement in accessibility. The decline of jobs is relatively small elsewhere. This is a consequence of a reduction in the cost of production especially in the City, where it reduces by 6%. (See figure 4.13 and table 4.4) The overall reduction for the Sub-region as a whole is 3%. The lower production costs are mainly due to the increased size of the labour pool, due to the improvement in public transport, easing the upward pressure on salaries. The slight reduction in rents and congestion are also factors that influence this result.

	Primary		Secondary		Tertiary		Retail		Private Serv.		Public Serv.		Total	
Camb. City	2	(100)	5	(100)	5	(100)	-2	(100)	93	(101)	217	(100)	320	(100)
South Cambs	-1	(100)	-2	(100)	-2	(100)	18	(100)	-23	(100)	-44	(100)	-52	(100)
East Cambs	-1	(100)	-1	(100)	-1	(100)	-1	(100)	-16	(99)	-65	(99)	-85	(100)
Hunts.	0	(100)	-2	(100)	-2	(100)	-15	(100)	-54	(99)	-108	(100)	-181	(100)
Total	0	(100)	0	(100)	0	(100)	0	(100)	0	(100)	0	(100)	0	(100)

Table 4.3 Public Transport Option 2016: Changes in location of employment by type compared to the Base case (2016 = 100)

Figure 4.10 Public Transport Option:
Changes in the location of employment

Camb. City	-142	(94)
South Cambs	-35	(98)
East Cambs	-27	(99)
Hunts.	-26	(99)
Average	-57	(97)

Table 4.4 Public Transport Option 2016: Change in cost of production £/month/employee compared to the Base case (2016 = 100)

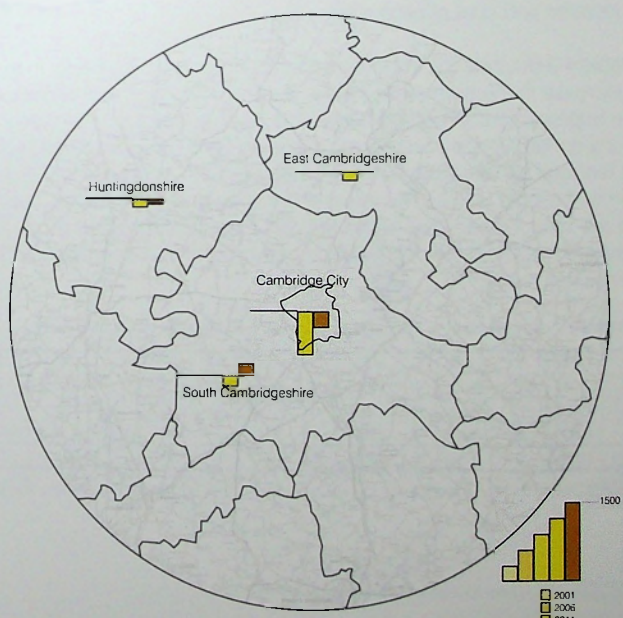
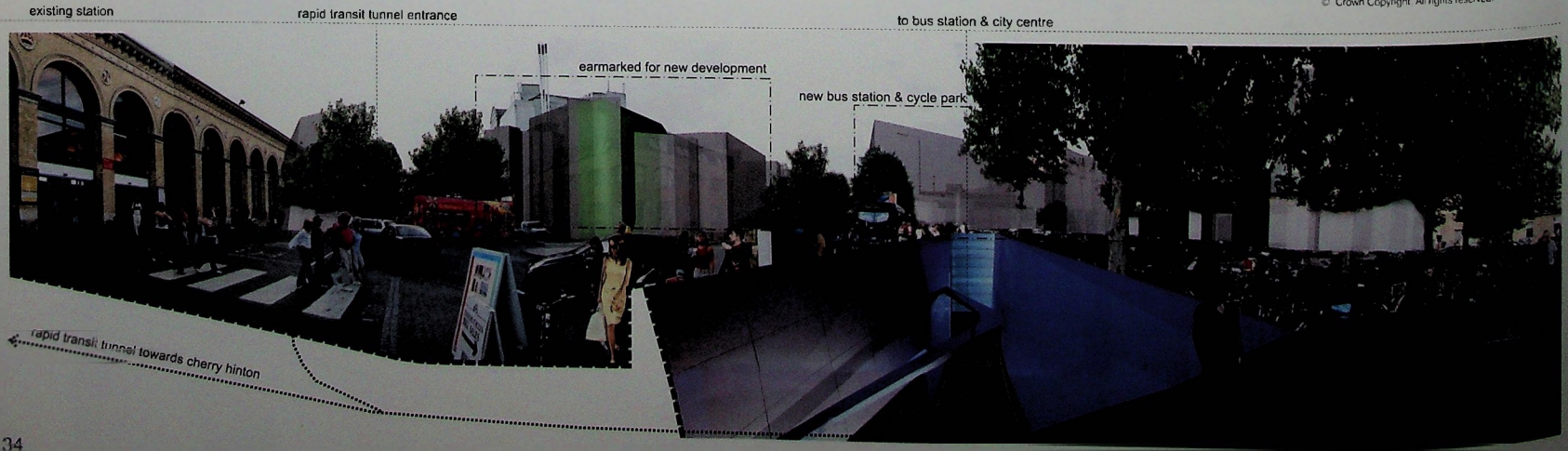


Figure 4.13 Public Transport Option: Change in the cost of production compared to the Base Case

Figure 4.9 Public Transport Option: possible new underground bus station next to rail station



4.4 Transport impacts

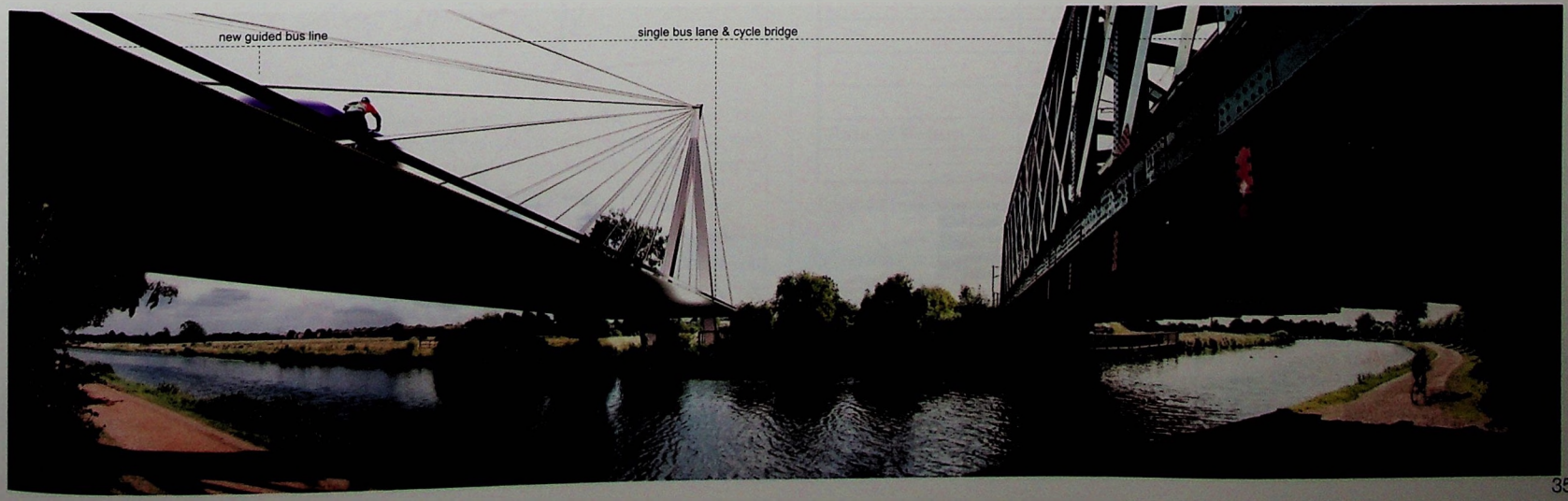
In the 3 hour morning peak period an additional 10,000 passengers use public transport, increasing the public transport modal share. The reduction in car traffic within the built up area is limited (1%) although delays reduce by 2% and traffic speed on main distributor roads improves by 13% to 15 miles per hour. The reason for the small impact in overall car traffic is probably because as people use more public transport, delays on the roads reduce, and some people are attracted back to cars. There would be an adverse environmental impact on Milton Road due to the loss of some green verges and cherry trees. There would be more traffic on Elizabeth Way and the eastern end of Chesterton Road, and some properties on the traffic island at Mitcham's Corner may need to be acquired for demolition, to make way for a dedicated bus crossing.

The construction of the tunnel and underground stations would cause substantial disruption during the construction period but this needs to be balanced against removing a large number of buses from the city centre streets and reducing car use in the central area as more people switch from using their cars to a fast and reliable public transport system. Construction impacts could be mitigated by bringing in much of the construction equipment and materials and removing the spoil by rail using the tunnel. *

Overall, the impact is positive as there is an improvement in travel time. Figure 4.15 illustrates the impact on speeds in the main road network and figure 4.16 illustrates the resulting changes in delays.

* The simulation model did not reduce road capacity to provide public transport priorities except on Milton Road between Elizabeth Way and Chesterton Road. Elsewhere it was assumed that the HQPT could be accommodated by the tunnels and loss of verges. If these measures are not part of the scheme, the HQPT would need to be allocated more road space and this would increase traffic congestion, making the option less beneficial to the economy and increasing vehicle emissions in the areas of increased congestion.

Figure 4.14 Public Transport Option: possible bridge across the Cam linking Chesterton to the east, accommodating high quality public transport, cycling and pedestrian routes.



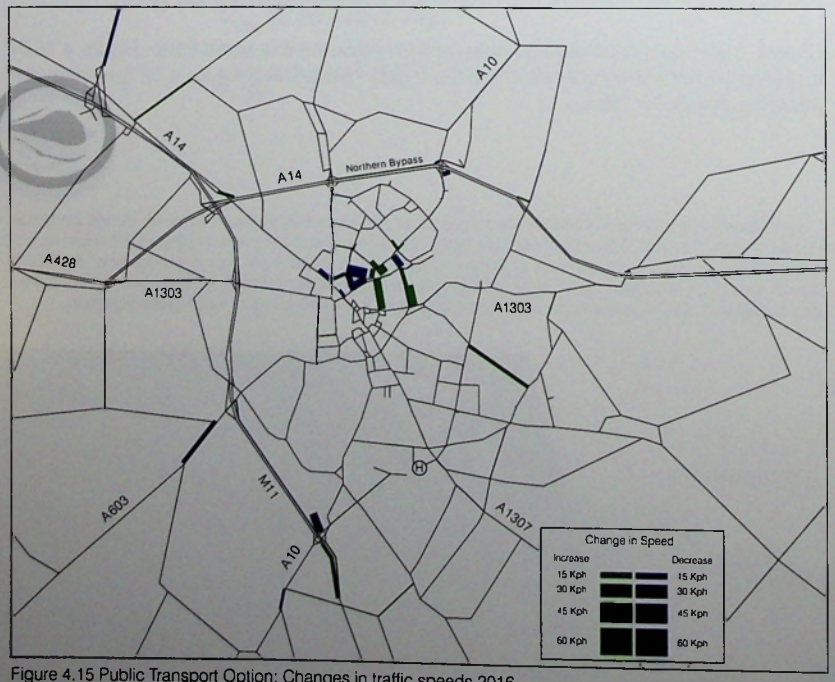


Figure 4.15 Public Transport Option: Changes in traffic speeds 2016

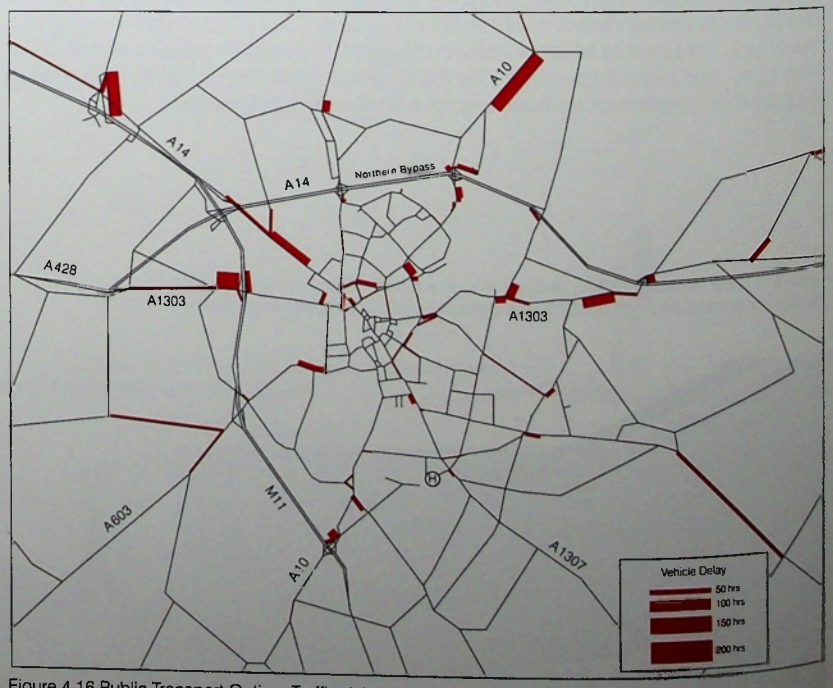


Figure 4.16 Public Transport Option: Traffic delays 2016

4.5 Feasibility of the Option

Investment costs

The investment costs are based on the assumption that the HQPT would be a guided-bus system, because guided bus is the most likely system to be implemented for the committed Huntingdon to Cambridge scheme. The public transport option would be an extension of that network.

- Tunnel costs are estimated at a maximum of £20,000 per metre per bore plus 100% for mechanical and electrical systems (ventilation, security, etc.). The total length of the tunnel is 2.7 km giving a cost of £216 million. In addition to this there would be a 25% contingency cost, making the final cost of the tunnel £270 million.

- Interchange costs for the railway and bus stations are estimated at a maximum of £50 million each. The intermediate interchange at Parker's Piece adds £20 million, making a total of £120 million.

- The guideway costs are estimated at £2.6 million per km, giving a total of £9.2 million for 3.5 km of new guideways. In addition there are costs of £1.2 million for a new unguided route and £5 million for traffic management, making a total of £15.4 million
- Total costs are therefore estimated at £405.4 million.

Annual benefits

- User benefits resulting from this option are estimated at £2.4 million per year. This includes a saving of £1.4 million mainly through the reduction in private car use, time saving valued at £2.6 million mainly due to increase in private and public transport speeds and a change in convenience valued at -£1.6 million.

- Operator benefits have not been estimated as there is no available information on the operating costs of bus companies. There could be savings due to the increased bus speeds.

- Government benefits have been estimated at -£0.1 million because of a reduction in fuel tax receipts.

- Total annual benefits are estimated at £2.3 million.

Rate of return

- The first year social rate of return is estimated by calculating the annual benefits divided by the investment costs, giving a 0.6% return.

Table 4.5 sumarizes the feasibility calculations

Investment Costs	Tunnel	270
	Interchanges	120
	Guideways	10.4
	Bridges	4
	Traffic Management	5
	Total Costs	**409.4**
Annual Benefits	User: tolls	-
	User: cost savings	1.4
	User: time savings	2.6
	User: convenience	-1.6
	User Total Benefits	**2.4**
	Operator: revenues	-
	Operator: costs	-
	Operator Total Benefits	**-**
	Government Benefits	**-0.1**
	Total Benefits	**2.3**
Rate of Return %	Social	**0.6%**
	Operator	-

Table 4.5 Public Transport Option: Summary of economic feasibility (£ millions /%)

Given the low rate of return, it would be necessary to opt for a cheaper traffic management alternative to reduce the capital costs which would give priority to buses using Station Road, Hills Road and Regent Street. However, it is necessary to cross the railway lines at the station to serve the east of Cambridge, which would mean building a tunnel or bridge. The cost of this would be in the region of £30 million. Additional investment would be needed to construct segregated bus lanes and improve traffic management.

Figure 4.17 shows a possible surface route between the railway station and the bus station. It would include a circulatory one-way system with a segregated guide-way at the approaches to the main junctions to give HQPT priority over other traffic. There would be a slight reduction in the road capacity, which would increase congestion and reduce the transport user benefits. However, the main disbenefit would be the impact of the frequent HQPT vehicles passing through the central shopping area near the bus station. The environmental impact could be mitigated if vehicles are powered through the city streets by electric or hydrogen to reduce noise and emissions. However, the physical presence of the vehicles would still have an adverse impact on the townscape by cluttering up the streets and creating severance and safety concerns for pedestrians and cyclists.

4.6 Sustainability implications

The proposed public transport option would improve the economic prosperity of the area. The overall production costs are reduced by 3% making the Sub-region more competitive in comparison with the Base Case. The 6% reduction of costs in the City of Cambridge is of particular significance because this is the location of a substantial amount of employment engaged in exporting goods and services to outside the Sub-region. The universities, high-tech and related services, retailers and public employers will all benefit.

The overall savings in production costs for exporters in the Sub-region are estimated at £90 million per year. This cost saving will make the area more competitive.

From the social point of view, this options offers people more choice of where to live, work, and obtain services, as well as increasing accessibility for non-car users. It would not alter the socio-economic structure of the sub region, maintaining a similar distribution to the Base Case. It would, however, particularly benefit higher income groups that commute to the City.

If the scheme includes the tunnel between the bus and rail stations it would improve the overall environmental impact by improving local air pollution and freeing up road space in the city centre for pedestrians and cyclists.

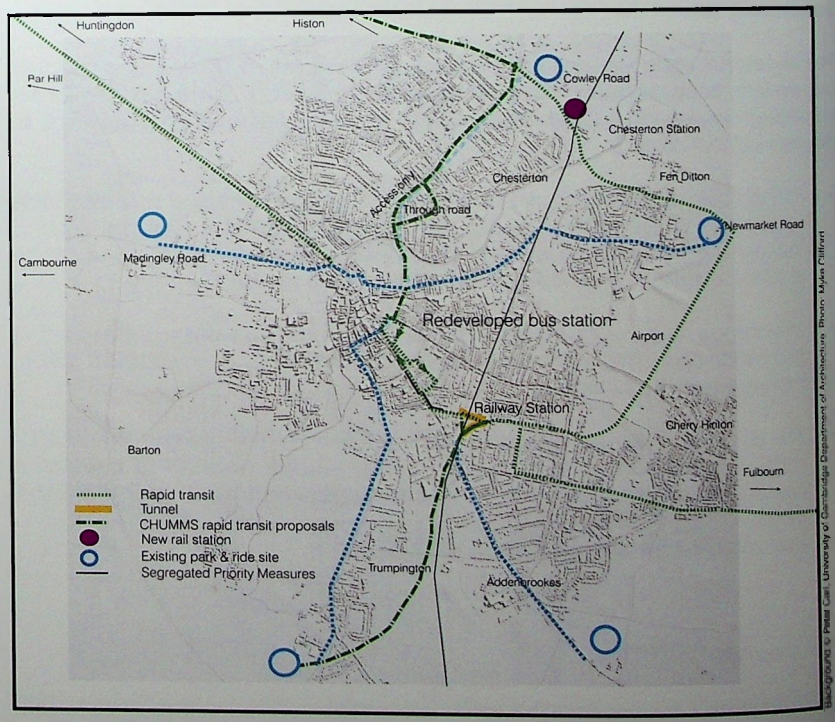


Figure 4.17 Public Transport Option: Alternative surface route for guided bus


oakington new settlement
west cambridge site
city centre
cambridge airport
bridge
grantchester meadows
addenbrookes
missleton hill tunnel
bridge
shelford tunnel

5 Orbital Option

5.1 Description

This option extends the road network improvements included in the Structure Plan [32] and connects the M11 and A14 around the south-east of Cambridge to cater for orbital movements whilst also linking the existing and proposed edge housing and employment sites. (See figure 5.1.) Drivers within Cambridge would be able to travel out to the orbital and then around the edge of the city to re-enter on the radial route that best serves their destination, thereby avoiding congested city centre streets. The objective of the orbital route is to reduce cars within the congested built up area. It also makes park and ride sites more accessible, enabling drivers to access the site whose buses pass closest to their destination. Longer distance traffic passing through and coming from the south-east areas of Cambridge would be able to use the orbital to avoid passing through the City centre. Newmarket Road would be widened to dual carriageway between the orbital and the A14 to the east. The junction between the orbital and Newmarket Road would be grade separated to provide the necessary capacity. Other junctions would be at-grade roundabouts. Airport Way can be dualled as illustrated in figure 5.2 to serve the new developments in the east. There would be a direct access link into the Addenbrookes hospital site and other developments on the edge of the city.

In view of the sensitivity of the route around the south east of the city, it has been assumed that part or all of this stretch of road near the Gog Magog area will be built in a tunnel, as illustrated in figures 5.3 and 5.4. There would also be a bridge over the railway and a tunnel under the Shelford Road.

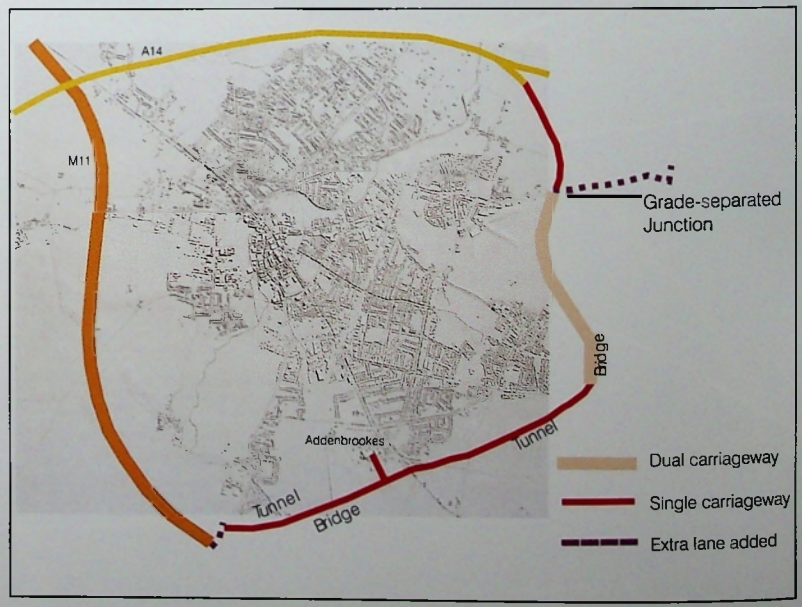


Figure 5.1 Orbital option: possible new road to create an orbital route around Cambridge

Figure 5.2 Orbital option: Airport Way can be dualled to form the eastern section of the orbital

5.2 Capacity issues

The simulation models did not indicate any delays on the M11 and A14 network in 2016 compared to the Base Case. However, some updating may be required in the existing growth assumptions used in the simulation model for through traffic on these trunk roads. It has been assumed, for the purpose of this study that committed improvements to the M11 and A14 included in the Base Case would provide sufficient surplus capacity to accommodate the extra circulatory traffic as a result of the orbital. If subsequent studies find that the main pinch points, on the M11/A14 junction and the Girton cutting cannot accommodate orbital traffic, then a link road could be provided between the A14 near Histon and the M11 near Madingley Road. This could be part of the orbital catering for local traffic with drivers only using the A14 and M11 for longer distance trips. Projected traffic levels for 2016 indicated that a dual carriageway road will be required between Newmarket Road and Cherry Hinton. Between Cherry Hinton and Trumpington a single carriageway would be adequate during the early stages of the scheme, but a corridor would need to be reserved for future widening.

Further detailed design and modelling would be necessary to assess the need for dual carriageways on the southern section, the separation of local traffic from long distance trunk road traffic, the type of junctions necessary, and the possible impacts on the M11 and A14.

Figure 5.3 Orbital option: possible tunnel in the south east sector to protect the visual link between the Gog Magog hill and Cambridge

Figure 5.4 Orbital option: possible dual carriageway serving the new developments at Addenbrookes and Clay Farm, forming the southern section of the orbital


city centre
cherry hinton
wandlebury
tunnel entrance
babraham road

5.3 Household location and cost of living

Figure 5.5 and Table 5.1 illustrate the location of households as compared with the Base Case. It can be observed that there is a 2% reduction of households living in the City. These households relocate to the South Cambs District, and to a lesser extent to the East Cambs District. Although all socio-economic groups move outside the City, there is a greater proportion of the higher income group (professional and managerial), that relocate. This last group has a higher car ownership and thus can take advantage of the highway improvements.

Figure 5.6 and table 5.2 illustrate the changes in the cost of living. It can be observed that the cost reduces by 17% in the City, mainly due to a relative reduction of the price of housing. The overall cost of living for the Sub-region, (that includes housing, transport and the cost of other goods and services), decreased by 8%. This cost reduction illustrates that there is a better balance between accessible housing and jobs. Note that the cost of living in the Sub-Region is still 31% higher than in 2001.

	SEG1		SEG2		SEG3		SEG4		Inact & Unem		Total	
Camb. City	-475	(97)	-221	(128)	-231	(97)	-191	(98)	-99	(100)	-1217	(98)
South Cambs	431	(102)	198	(130)	182	(101)	229	(103)	210	(101)	1250	(102)
East Cambs	206	(104)	171	(100)	146	(103)	59	(102)	-61	(99)	521	(102)
Hunts.	39	(100)	-32	(103)	-27	(100)	-40	(100)	-50	(100)	-110	(100)
Total	202	(100)	116	(117)	70	(100)	57	(100)	0	(100)	444	(100)

Table 5.1 Orbital Option 2016: Changes in household location compared to the Base case (2016 = 100)

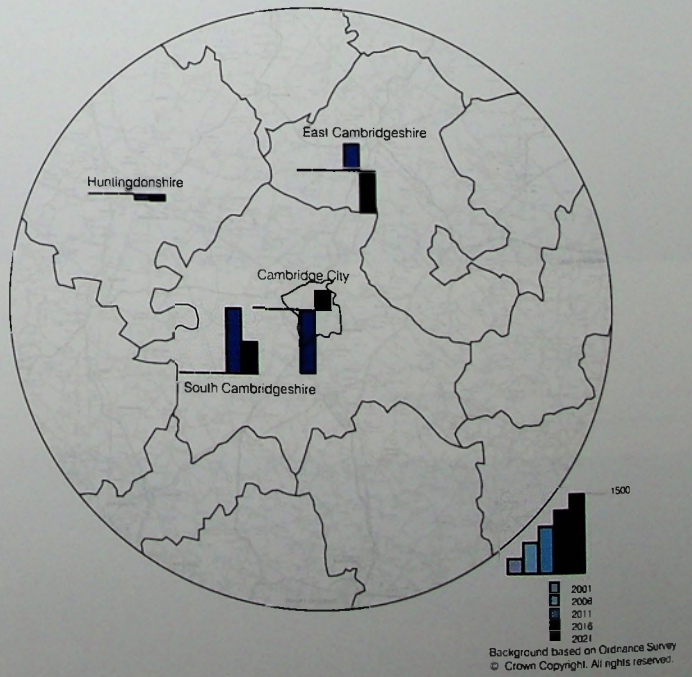


Figure 5.5 Orbital Option: Changes in household location compared to the Base case.

5.4 Employment location and production costs

There is a small increase in jobs in both the City and South Cambs as the Orbital Option improves the access of customers and employees to firms in the area. The number of jobs reduces slightly in the Hunts and East Cambs. districts (see figure 5.7 and table 5.3). There is an 11% saving in production costs in the City with respect to the Base Case, although these costs are still 22% higher than in 2001 (see figure 5.8 and table 5.4). The lower cost of living induces lower salary costs compared to the Base Case. These cost reductions combined with transport cost savings make the Sub-region more economically attractive which, as a whole, has a 5% reduction in production costs.

Camb. City	-738	(83)
South Cambs	-71	(98)
East Cambs	-66	(97)
Hunts.	-58	(98)
Average	-254	(92)

Table 5.2 Orbital Option 2016: Changes in household cost of living (£/month) compared to the Base case (2016 = 100)

	Primary		Secondary		Tertiary		Retail		Private Serv.		Public Serv.		Total	
Camb. City	8	(100)	9	(100)	8	(100)	-63	(100)	113	(101)	432	(101)	507	(100)
South Cambs	-1	(100)	0	(100)	-3	(100)	150	(101)	1	(100)	167	(101)	314	(100)
East Cambs	-1	(100)	-1	(100)	-1	(100)	-10	(100)	-23	(99)	-173	(97)	-209	(99)
Hunts.	-6	(100)	-8	(100)	-4	(100)	-77	(99)	-91	(98)	-426	(99)	-612	(99)
Total	0	(100)	0	(100)	0	(100)	0	(100)	0	(100)	0	(100)	0	(100)

Table 5. 3 Orbital Option 2016: Changes in employment location by type compared to the Base case (2016 = 100)

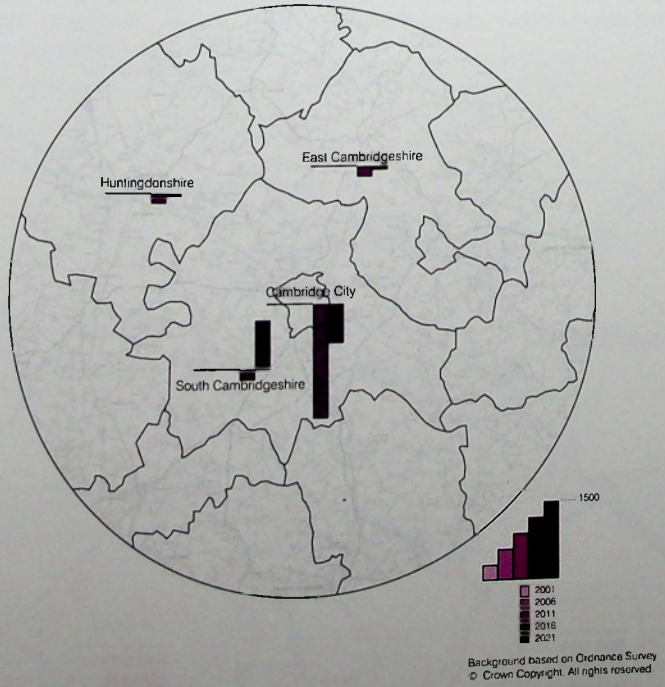


Figure 5.6 Orbital Option: Changes in household cost of living compared to the Base case

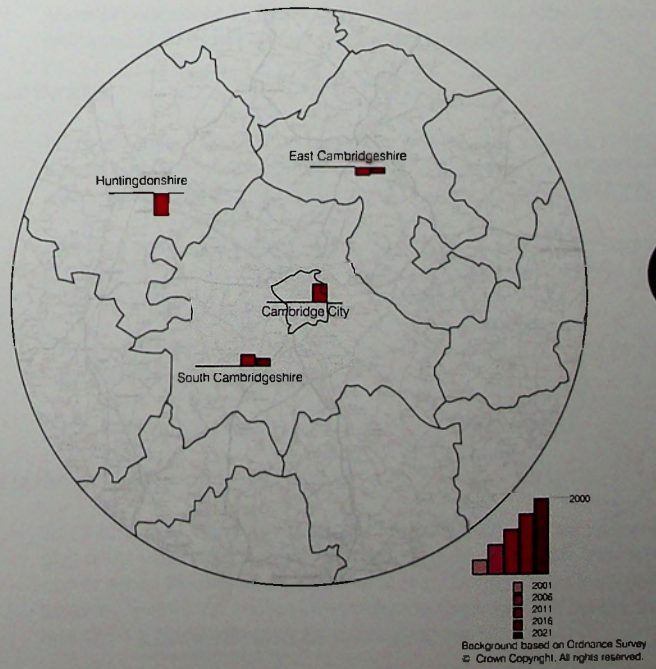


Figure 5.7 Orbital Option: Changes in employment location compared to the Base Case

Camb. City	-263	(89)
South Cambs	-100	(95)
East Cambs	-68	(97)
Hunts.	-34	(98)
Average	-116	(95)

Table 5.4 Orbital Option 2016: Changes in production cost (£/month/employee) compared to the Base case (2016 = 100)

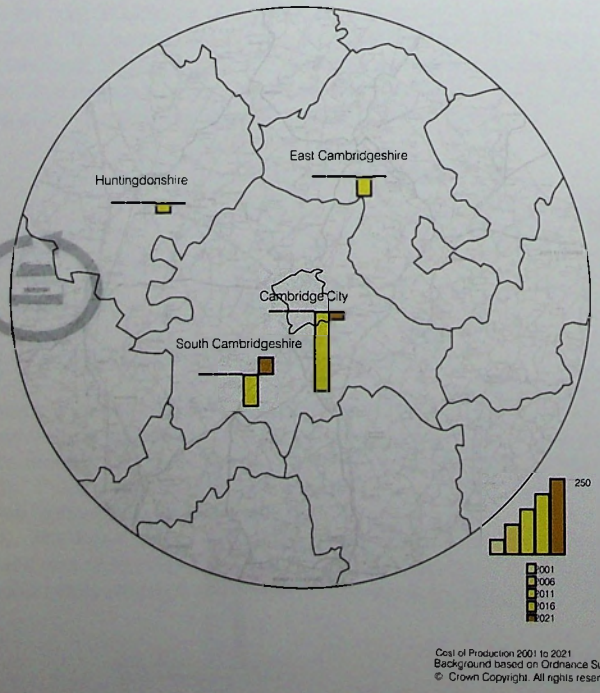


Figure 5.8 Orbital Option: Changes in production cost compared to the Base case.

5.5 Transport impacts

The orbital option reduces car traffic within the City by 6%, but increases the car traffic around the Cambridge built up area by 19% and average speeds improve.
Figures 5.9 and 5.10 illustrate the changes in delays and speeds caused by the introduction of the orbital option. Table 5.5 illustrates the changes in traffic in selected links of the main network. It can be seen that in the main radial roads there is a reduction of delays (e.g. Huntingdon Road, Histon Road, Milton Road, Coldhams Lane, Madingley Road, Barton Road, Babraham Road, Cherry Hinton, Newmarket Road, etc.). The reduction of congestion due to the orbital road is especially noticeable in the east of Cambridge.

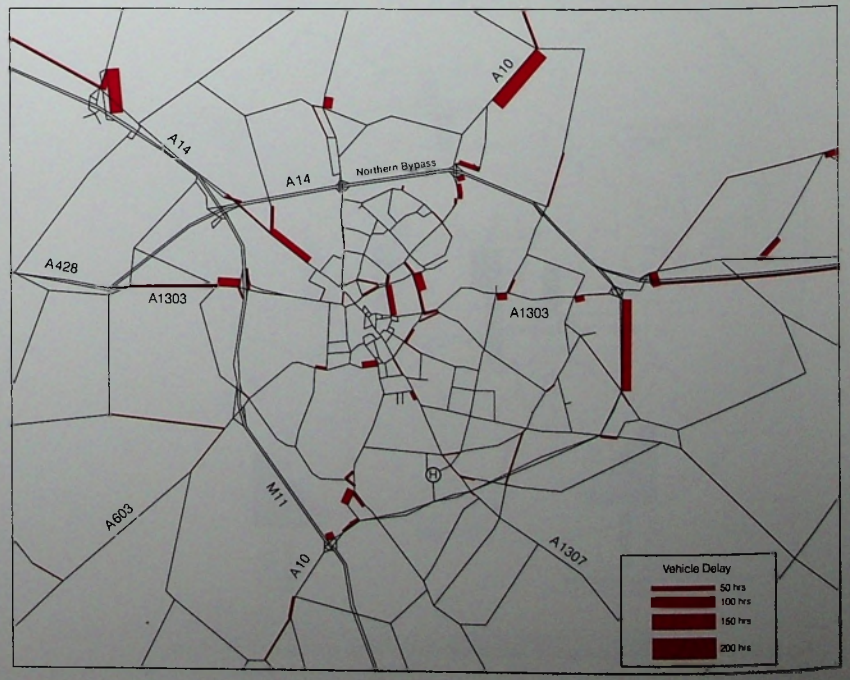


Figure 5.9 Orbital Option: Changes in traffic delays

The orbital would have an environmental impact on the southern and eastern fringes of Cambridge. The orbital passes through, or along, the edge of proposed developments, so this will lessen its impact on the future landscape. The orbital could incorporate a combination of landscape mounding, noise barriers and planting to reduce the noise impacts on existing and proposed development. Tunnels would reduce the impact on the Gog Magog Hills and Shelford. The main impacts would be on west Teversham, the area between Fulbourn and Cherry Hinton, (where some single storey NHS buildings would need to be acquired and demolished to make way for a bridge over the railway), the area near the Wort's Causeway, Limekiln Road junction, and properties near where the orbital would cross Babraham Road and Shelford Road. These adverse environmental impacts need to be weighed against the positive environmental benefits of less traffic congestion in the city centre.

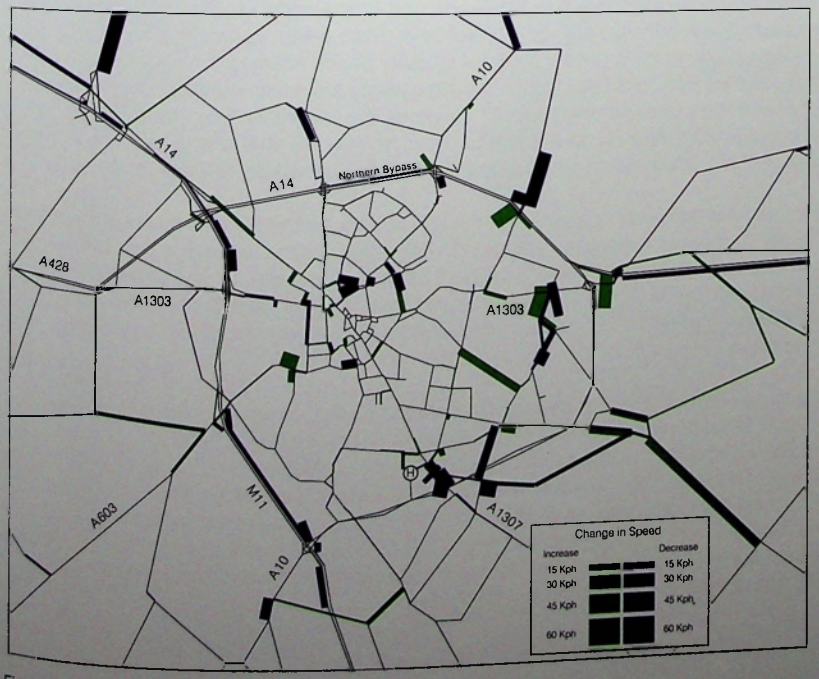


Figure 5.10 Orbital Option: Changes in vehicle speeds compared to the Base case

5.6 Feasibility of the Option

Cost of investment

- It has been estimated that the total cost of the 11 km dual carriageway linking the M11 with the A14, to form an orbital road around Cambridge, will be approximately £50 million including bridges, under passes and junctions. Providing a 1.3 km tunnel for the south eastern section would add £80 million. The orbital road would make redundant the committed link road from Hauxton Road (A1309) to serve the proposed developments in the Clay Farm and Addenbrookes area included in the Base Case. The total capital cost is thus estimated at £120 million for comparison purposes.

Annual Benefits:

- Transport users benefit from less traffic congestion, saving £1.1 million in money and £6.4 million in time. In addition there is a convenience improvement valued at £6 million. The overall annual benefit is estimated at £13.5 million.
- Transport operators, especially bus operators, would benefit from the increase in speed on the main roads, but this has not been calculated in monetary terms for this study.
- The government would receive fuel tax receipts amounting to £1.3 million due the longer travelling distances.
- The overall annual benefits are estimated at £14.8 million.

Rate of Return

- The total annual benefits can be compared with the capital investment cost to give a first year rate of return of 12.3%. It is likely that with the resulting social rate of return the project is attractive and could be funded from government taxation. Even if the cost of investment doubles, to £240 million, the resulting rate of 6.1% is still attractive for public projects.

Table 5.5 summarizes the economic feasibility of this option

Investment Costs	Orbital highway	50
	Tunnel	80
	Link Road	-10
	Total Costs	**120**
Annual Benefits	User: tolls	-
	User: cost savings	1.1
	User: time savings	6.4
	User: convenience	6
	User Total Benefits	**13.5**
	Operator: revenues	-
	Operator: costs	-
	Operator Total Benefits	**-**
	Government Benefits	**1.3**
	Total Benefits	**14.8**
Rate of Return %	Social	**12.3%**
	Operator	**-**

Table 5.5 Orbital Option: Summary of economic feasibility (£million/%)

5.7 Sustainability implications

The economic efficiency of the Orbital Option is high as it makes a larger supply of dwellings and business floorspace accessible, therefore making the economy more competitive and thus reducing costs. It is clearly noticeable that the City of Cambridge benefits more than the other districts as there is less upward pressure on housing costs, and thus on the cost of living. This is reflected in lower pressure for salary increases and thus a reduction in the cost of production, which would help to maintain the competitiveness of the Sub-region. It is estimated that exporters in the City would save about £75 million in annual costs of production. The overall savings for the Sub-region are estimated at £176 million per annum.

The results do not alter significantly the present social mix of the area. There is, however, a slight proportional increase in the South and East Cambs districts of higher income groups that may improve the social balance in those areas. Lower income groups also take advantage of the improved access to lower priced housing in the surrounding districts. The benefits in terms of cost of living savings are reasonably distributed throughout all of the socio-economic groups. However, the middle income group SEG2 - clerical and administrative - receive more benefits, as they are able to take advantage of the reduction in costs in South Cambs and Cambridge City where they are concentrated.

From an environmental point of view, the orbital option produces mixed results. On the one hand, there is a positive reduction in car traffic within Cambridge with the consequent increase in average speeds and reduction in emissions. On the other hand, there is an increase in car travel in the sub region that negates the reduction within the City. The overall impact on fuel consumption and carbon emissions is 16% higher than the Base Case.

The visual impact of the orbital can be reduced by the construction of a 1.5 km tunnel through Missleton hill between Wort's Causeway and Fulbourn Road, thus minimising the disturbance to the natural landscape of the Gog Magog hills, south east of Cambridge. The rest of the orbital to the South and East of Cambridge would have a minor impact on the landscape, as it will be on the edge of the development around Addenbrookes, at Clay Farm to the south, and around the airport to the east. The orbital would reduce congestion in accessing Addenbrookes and could help to solve the crossing of the railway lines to the south and east of the City.


oakington new settlement
west cambridge
city centre
cambridge airport
grantchester meadows
addenbrookes hospital
existing park & ride
new congestion charge
background
base
cycling & walking
airport
orbital road
congestion charge

6 Congestion Charging Option

6.1 Description

Charging for the use of roads is an effective way of managing the demand for road space, as shown by the London congestion charging scheme [33]. It reduces congestion, thereby improving average speeds and reducing vehicle emissions. The drawback of this option is that car users would have to pay a toll if they wanted to continue to drive in Cambridge, making them worse off. However, those paying for the use of the road will have the benefit of reduced travel time and reduced fuel consumption, that goes some way towards compensating for the charge. There must be alternative ways of travelling for those who do not want to pay the charge in order to make this option publicly acceptable.

Cambridge Futures tested the congestion charging option as follows:

- Peak period charging. Between 7am and 10am and between 3.30pm and 6.30pm a charge of £3.50 per day would be levied on cars entering or leaving the congestion pricing zone.

- Internal charging. For people using their cars wholly within the congestion zone the charge would be 50 pence per day.

- The congestion charge zone could be defined as illustrated on the previous page, with the A14 as a northern boundary, the position of the orbital (if built) for the eastern and southern boundaries and the M11 as the western boundary. If the orbital is not built, the eastern boundary could run along Airport Way, east of Cherry Hinton, then across the roads, entering the built up area at Fulbourn Road, Hills Road and Shelford Road. The actual location of the boundary would be a politically sensitive issue.

People travelling into Cambridge would be able to access all park and ride sites and parking at Addenbrookes hospital without being charged.

- The operation of the congestion charging could be similar to the London system where the car users can pay in advance of entering the area or up to 10pm of the day of entering, with payments being made in shops, by credit card over the telephone, or by other means, such as debits from a credit account. Enforcement is by video cameras set up in suitable locations on the access roads and roving detector vehicles in the charging zone. The cameras identify the license plate, which is then checked against the payments information held on computers. If after the deadline payments are not received, a traffic fine is issued (see figure 6.1). The technology for monitoring and administering congestion charging schemes is constantly improving and a more sophisticated scheme may be feasible in the future.

Figure 6.1 Congestion charging option: cars are identified by TV cameras entering the congestion charging area

Work place parking charges were considered as a method of demand management alternative to congestion charging. However, work place parking charges are likely to be less effective because only employees using parking spaces provided by employers are affected. If fewer of these employees use their cars, the road space made available is likely to be filled by the demand for other types of trip, such as personal business and the school run. Thus the impact of the working place parking charge is likely to be less effective than the congestion charge. It is more discriminatory against the firms employing people, that would be in effect be taxed, but with little benefit in terms of improved transport.

6.2 Household location and cost of living

Figure 6.3 and table 6.1 illustrate the impact of introducing congestion charging in the Cambridge Sub-region. There is a move by working households to locate within the congestion charging area to avoid paying the charge. This area would also have an improved environment. The relocation of households is particularly noticeable in the long run (e.g. 2021). Working households tend to move into Cambridge City from the South Cambs district as illustrated in figure 6.3. The most noticeable changes are in SEG1: Managerial and Professionals and SEG2: Administrative and Clerical. Huntingdonshire, and to a lesser extent East Cambs, get an increase in the number of households. Inactive (retired) households tend to move out of the City because of the higher cost of living.

	SEG1		SEG2		SEG3		SEG4		Inact & Unem		Total	
Camb. City	258	(102)	442	(103)	192	(102)	67	(101)	-978	(95)	-19	(100)
South Cambs	-898	(95)	-853	(94)	-503	(96)	-354	(96)	98	(101)	-2510	(96)
East Cambs	36	(101)	17	(100)	46	(101)	58	(102)	319	(103)	476	(102)
Hunts.	229	(102)	254	(102)	243	(102)	279	(103)	561	(103)	1566	(102)
Total	-375	(99)	-140	(100)	-22	(100)	50	(100)	0	(100)	-487	(100)

Table 6.1 Congestion Charging Option 2016: Changes in household location by SEG compared to the Base Case (2016 = 100)

Camb. City	400	(109)
South Cambs	241	(107)
East Cambs	63	(103)
Hunts.	50	(102)
Average	208	(106)

Table 6.2 Congestion Charging Option 2016: Changes in household cost of living (£/month) compared to the Base Case (2016 = 100)

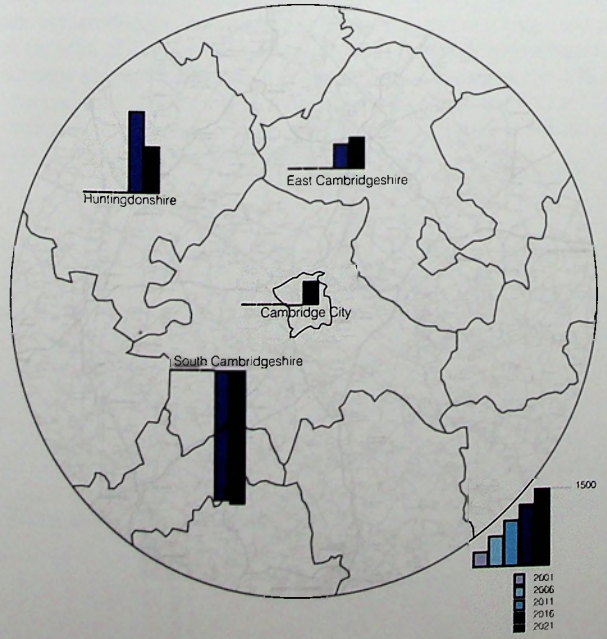


Figure 6.3 Congestion Charging Option: Changes in household location compared to the Base Case

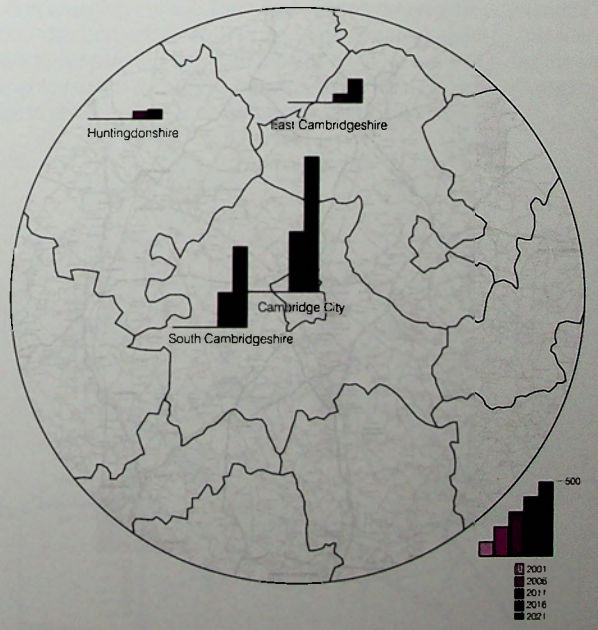


Figure 6.4 Congestion Charging Option: Changes in household cost of living compared to the Base Case

The cost of living increases by 9% in the City, reflecting the combined effect of higher transport cost and higher rents (see figure 6.4 and table 6.2). The average cost of living for the whole of the sub region increases by 6%.

	Primary		Secondary		Tertiary		Retail		Private Serv.		Public Serv.		Total	
Camb. City	-4	(100)	-10	(100)	-9	(100)	-689	(96)	-450	(94)	-2517	(95)	-3679	(97)
South Cambs	0	(100)	-1	(100)	4	(100)	150	(101)	294	(103)	717	(104)	1164	(102)
East Cambs	1	(100)	1	(100)	1	(100)	84	(102)	18	(101)	386	(106)	491	(102)
Hunts.	3	(100)	10	(100)	4	(100)	455	(104)	138	(103)	1414	(105)	2024	(103)
Total	0	(100)	0	(100)	0	(100)	0	(100)	0	(100)	0	(100)	0	(100)

Table 6.3 Congestion Charging Option 2016: Changes in employment location by type compared to the Base Case (2016 = 100)

Camb. City	253	(111)
South Cambs	86	(104)
East Cambs	46	(102)
Hunts.	23	(101)
Average	102	(105)

Table 6.4 Congestion Charging Option 2016: Changes in production cost (£/month/employee) compared to the Base Case (2016 = 100)

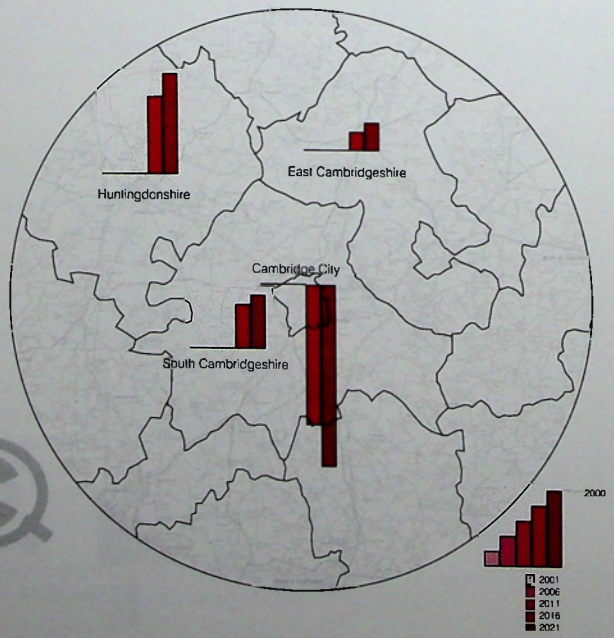


Figure 6.5 Congestion Charging Option: Changes in employment location compared to the Base Case

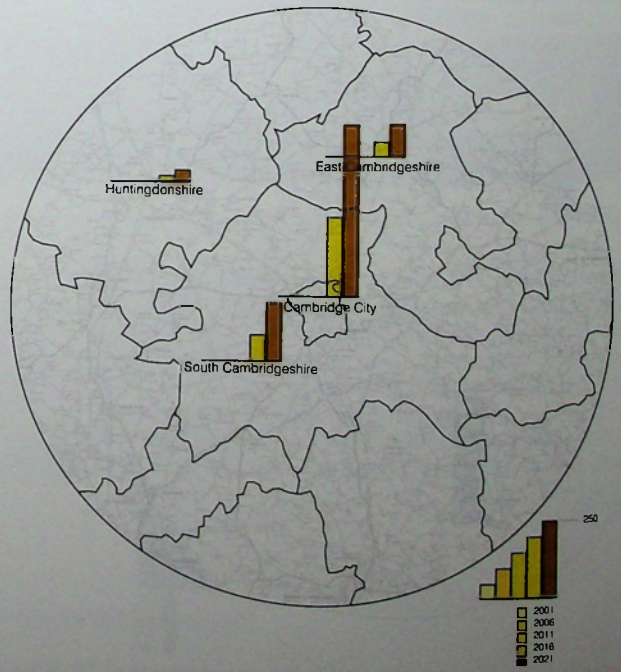


Figure 6.6 Congestion Charging Option: Changes in production costs compared to the Base Case

6.3 Employment location and cost of production

There is a 3% reduction in employment within the City as a result of the policies, as illustrated in figure 6.5 and table 6.3. Some employment sectors, such as retail, private and public services, are more affected than others. The lower employment and the increase in working households brings a more balanced distribution of jobs and dwellings in the future with a greater proportion of people working in the City living in the city.

The simulation model shows other districts would benefit from the slow down in the City's economy as jobs move out of the city. Some of these jobs could be lost from the Sub-region entirely, but the model is not set-up in a way that can simulate this. The cost of production increases overall by 5% due mainly to higher salaries to compensate workers for the rise in transport and housing costs (see figure 6.6 and table 6.4).

6.4 Transport impacts

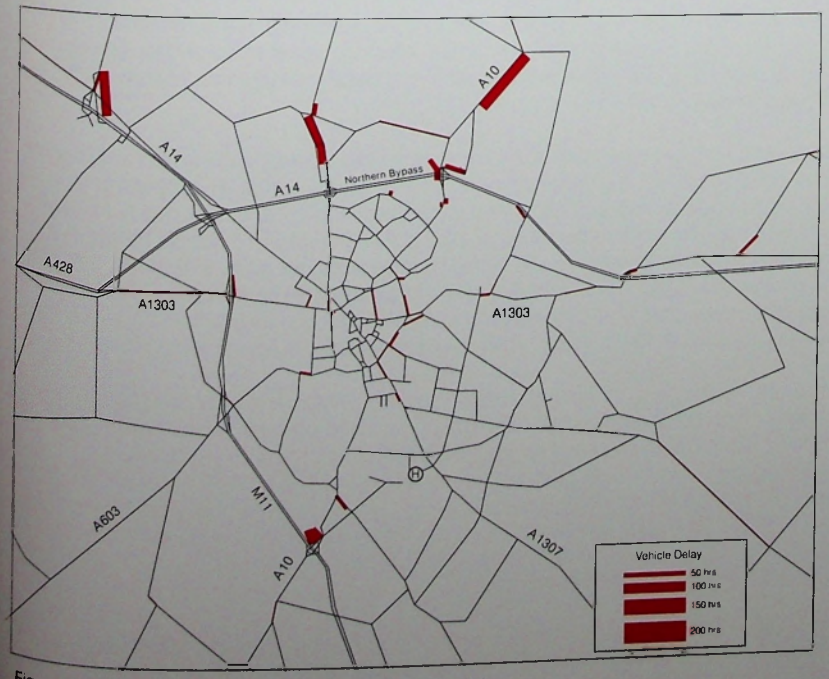
There is a dramatic impact on traffic, especially on the access roads into Cambridge. During the 3 hour morning peak period there could be 49% less traffic entering Cambridge, reducing delays by 29% overall and improving average speeds on the radial roads by 40% from 12 to 17 miles per hour. However, vehicle trips with both an origin and destination within Cambridge increase by 15% as people in the City take advantage of the improvement in traffic conditions. Car traffic in the Sub-region reduces by 3% overall, with an equivalent reduction in carbon emissions

Figure 6.7 illustrates the delays resulting from the congestion charge on selected main roads in Cambridge. As previously explained, the estimates of trunk traffic around the built up area of Cambridge appear to have been underestimated. It is noticeable that practically all main roads are at or below capacity except the A10 at Milton, that is 14% above capacity. The simulation model indicates that the A10 at Milton requires dualling to improve the congestion in all options tested. Figure 6.8 illustrates the impact of the congestion charge on speeds of selected roads.

6.5 Feasibility of the Option

Investment costs

- The values used for costs in this option are based on the London congestion charging scheme (see Local Transport Today, 23rd January 2003) [34]. The investment for the supply of TV cameras, telecommunication networks and ancillary items are relatively low. Assuming that the Cambridge system costs a quarter of the London system, the capital cost would be about £8 million. (In reality this would probably be much less, as there would be fewer entry points to the congestion charging zone.) The London scheme also included major investment in public transport improvements and traffic management to provide a viable alternative to car use and deal with the traffic that re-route to avoid the scheme. These elements have not been included in the option tested by Cambridge Futures in order to show the effect of congestion charging in isolation.



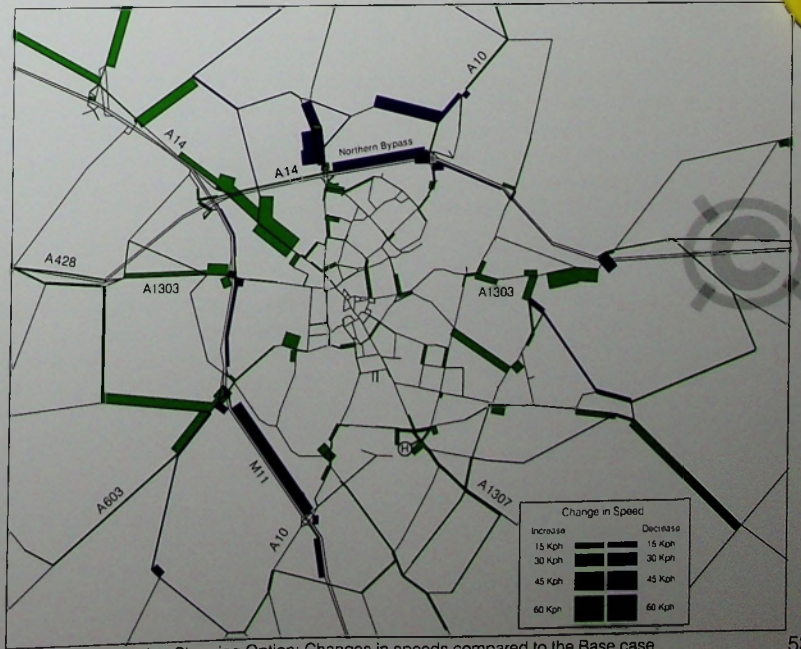


Figure 6.8 Congestion Charging Option: Changes in speeds compared to the Base case

Annual benefits

- User benefits are negative. Users pay £41.4 million to the operator in 2016, but saves £3.3 million in transport due to improved speeds and changes to cheaper modes of transport. The user benefits, in monetary terms, are therefore -£38.1 million (cost). Benefits due to reduction of travel time are estimated at £20.6 million. Convenience and mobility reduction are estimated at -£6.1 million. The overall user benefits are therefore -£23.6 million.

- The operator of the system would receive £41.4 million in tolls. The estimated cost of collection and management of the system is based on the London scheme cost of £1.25 per chargeable car, entering or leaving the area. This gives a total cost of £8.1 million with a net benefit of £33.3 million.

- The government benefits reduce by £2.8 million because of the reduction in fuel tax revenues.

- The overall annual benefit is therefore £6.9 million.

Rate of return

Given the capital cost of £8 million and an annual net benefit of £6.9 million the social rate of return is 86.3%. An investor in the system (e.g. Local Authority), would receive an annual net benefit of £33.3 million with an investment of £8 million, thus the 'private' one year rate of return for the investor is over 400%. It is however expected that the income received by the authority would be reinvested into transport improvements during the 10 year hypothecation period. See table 6.5.

6.6 Sustainability implications

The proposed congestion charging option may reduce the economic prosperity of the Cambridge Sub-region, unless accompanied by other complementary measures. The increase in transport costs affects household living costs, which in turn, affect the salary costs of employers. Cambridge employers find great difficulties in attracting labour, and with the introduction of the congestion charge, it would make recruitment even more difficult. Central area retailers would also be affected as fewer customers would be prepared to drive into Cambridge to patronise the shops.

It is estimated that local employers that trade outside the Sub-region, ('exporters'), especially those in the City of Cambridge, will face an increase in production costs of £160 million per annum. This is much more than the collected tolls and it is due to an increase in housing costs within the charging area. The increases in housing prices, transport costs, and salaries demanded by employees leads to higher prices that result in increased costs to exporters.

Investment Costs	Equipment etc.	8
Annual Benefits	User: tolls	-41.4
	User: cost savings	3.3
	User: time savings	20.6
	User: convenience	-6.1
	User Total Benefits	**-23.6**
	Operator: revenues	41.4
	Operator: costs	-8.1
	Operator Total Benefits	**33.3**
	Government Benefits	**-2.8**
	Total Benefits	**6.9**
Rate of Return %	Social	**86.3%**
	Operator	**416%**

Table 6.5 Congestion Charging Option: Summary of economic feasibility (£ million/%)

If they are able to pass-on the increases to their customers, it may not affect the Sub-region economy, but there is certainly a risk of losing market share and thus production. If, as is more likely, the exporters are unable to pass the increases to their customers, they would suffer a reduction in profits.

However, the higher revenues for the local authorities operating the system would somewhat compensate for the increase in the cost of production. It all depends on how the surplus revenue is spent. The revenues can be used by a local authority to invest in transport improvements, such as improved public transport. If people believe that the money would be used more wisely by the local authorities than by individuals, the charging programme may be acceptable. However, it should be noted that, current legislation only guarantees that local authorities can use this revenue for investment in local transport improvements for 10 years. After that, the Treasury is able to keep the revenues.

From the social point of view this option would penalise the high and middle income groups. The high income socio-economic group of professional and managers will be worse off in terms of cash, but compensated in terms of reduction in travel time. Lower income groups are less affected, as they tend to live within the City in social housing and travel less by car. They may experience some benefits in terms of improvement in public transport performance. However, those low income people who do need to drive into Cambridge during peak periods would be adversely affected because the toll would be a larger proportion of their disposable income, than for higher income groups.

It would improve environmental sustainability with an overall 9% reduction in carbon emissions and fuel consumption, and less local air pollution.


oakington new settlement
new chesterton
west cambridge
centre
cambridge airport
bridge
grantchester meadows
tunnel
addenbrookes
railway line
guided bus
extension to guided bus
existing park & ride
orbital
congestion charge cameras
bridge
tunnel
background
base
cycling & walking
public transport
orbital road
congestion charge
combined
comparison

7 Combined Option

7.1 Description

This option tests how all of the individual options would work together in combination. i.e. it combines all of the measures comprising cycling and walking, public transport, orbital highway and congestion charging options. Combinations of fewer individual options have not been tested due to the limitations on the resources available for this study.

The orbital road would help to remove traffic from the city, offering drivers the opportunity to travel to edge city employment centres such as Addenbrookes Hospital, University West site, Science Park and Airport area without congesting the urban roads while the congestion charge would deter people from driving into the City. Public transport would be improved and the orbital highway would also provide drivers with good access to the park and ride site that best serves their destination without having to pay the congestion charge.

7.2 Household location and cost of living

Figure 7.1 and table 7.1 show how the Combined Option affects household location. There is a significant reduction of households living in the City by 2016. This is due to areas further from Cambridge becoming more accessible by public transport and highways. Huntingdonshire and East Cambs districts receive the bulk of the increases in households.

Figure 7.2 and table 7.2 show that the cost of living in Cambridge reduces significantly (20%), mainly due to the reduction in housing prices as there is less demand in the City. The other districts are not significantly affected, except South Cambs where costs increase beyond 2016. The prices in Cambridge are contained because the improved transport accessibility makes it more likely that people working in Cambridge will choose to live in surrounding districts.
It is remarkable that the average cost of living for the Sub-region is substantially lowered with this option (-28%). This reduction means that the cost of living in the area by2016 would not differ from the 2001 value.

	SEG1		SEG2		SEG3		SEG4		Inact & Unem		Total	
Camb. City	-776	(95)	-277	(98)	-325	(96)	-435	(95)	-841	(96)	-2654	(96)
South Cambs	47	(100)	-242	(98)	-26	(100)	183	(102)	389	(102)	351	(100)
East Cambs	383	(107)	330	(108)	222	(105)	142	(104)	183	(102)	1260	(105)
Hunts.	337	(102)	240	(102)	242	(102)	269	(103)	269	(101)	1357	(102)
Total	-9	(100)	51	(100)	114	(100)	158	(101)	0	(100)	314	(100)

Table 7.1 Combined Option 2016: Changes in household location by SEG with respect to the Base Case (2016 = 100)

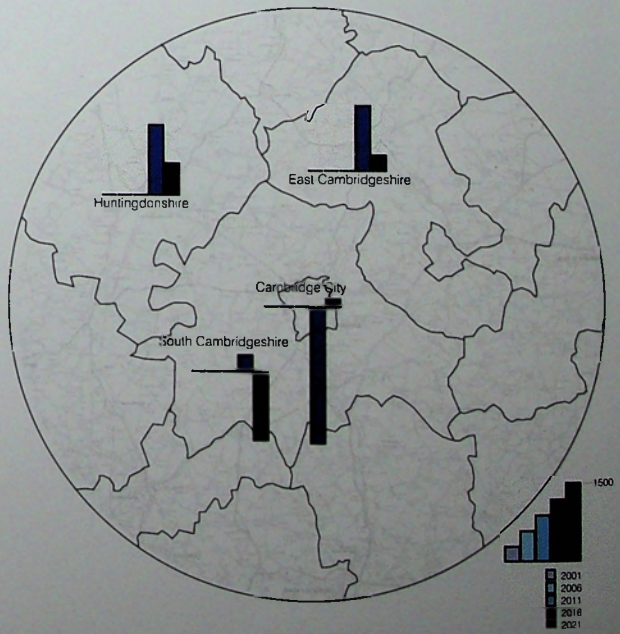


Figure 7.1 Combined Option: Changes in household location compared to the Base case

Camb. City	-897	(80)
South Cambs	121	(104)
East Cambs	-49	(98)
Hunts.	-37	(99)
Average	-918	(72)

Table 7.2 Combined Option 2016: Changes in household cost of living (£/month) compared to the Base Case (2016 = 100)

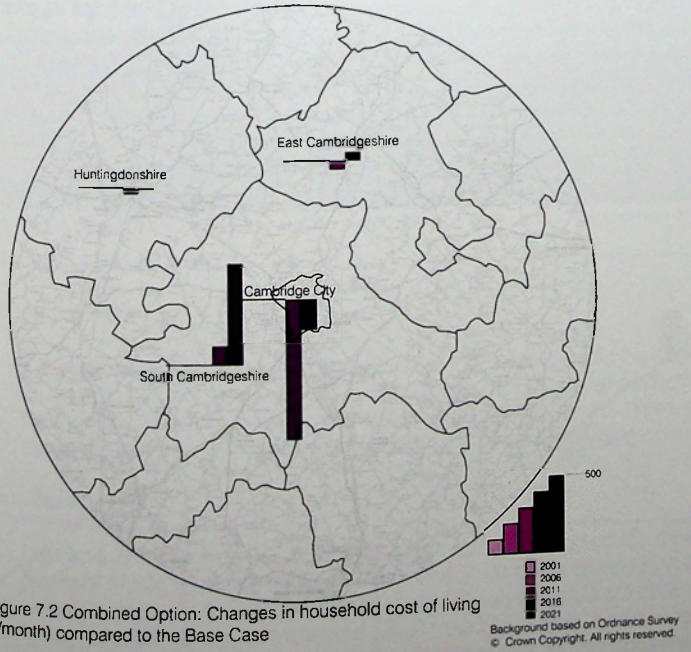


Figure 7.2 Combined Option: Changes in household cost of living (£/month) compared to the Base Case

	Primary		Secondary		Tertiary		Retail		Private Serv.		Public Serv.		Total	
Camb. City	6	(100)	12	(100)	11	(100)	-927	(95)	-180	(98)	-2289	(95)	-3367	(97)
South Cambs	-2	(100)	-6	(100)	-6	(100)	426	(104)	230	(102)	1154	(106)	1796	(103)
East Cambs	-1	(100)	-1	(100)	-1	(100)	90	(102)	-25	(98)	151	(102)	213	(101)
Hunts.	-3	(100)	-5	(100)	-4	(100)	411	(103)	-25	(99)	984	(103)	1358	(102)
Total	0	(100)	0	(100)	0	(100)	0	(100)	0	(100)	0	(100)	0	(100)

Table 7. 3 Combined Option 2016: Changes in employment location by type compared to the Base Case(2016 =100)

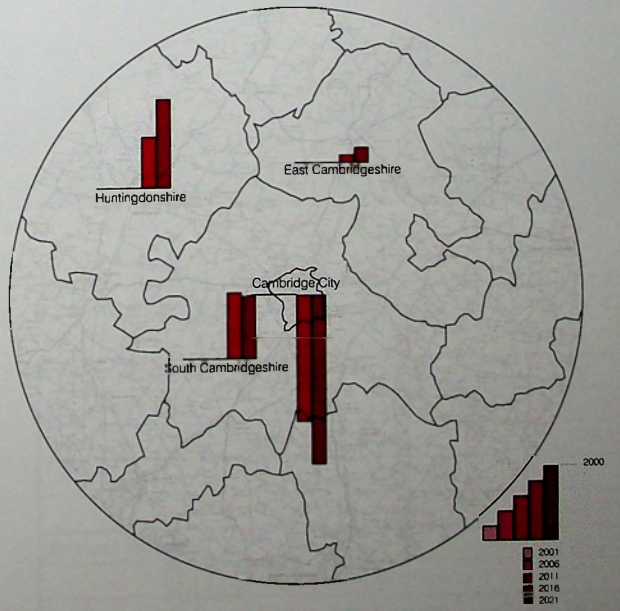


Figure 7. 3 Combined Option: Changes in employment over time compared to the Base Case

7.3 Employment location and cost of production

There is a 3% reduction in employment in the city. South Cambs and Huntingdonshire benefit, with an increase in employment, bringing jobs and housing more into balance (see figure 7.3 and table 7.3).

Figure 7.4 shows the changes in cost of production compared to the Base Case. Production costs are significantly lower in the city (11%), and there is practically no change in the surrounding districts. The pressure for higher salaries is lessened by a reduction in the cost of living. The overall production costs for the Sub-region would be 4% lower than the Base Case in 2016.

This reduction of cost makes it more likely that the high level of growth catered for in the Structure Plan can be sustained. However, production costs would still be 18% higher than in 2001 despite the range of transport measures included in the combined option.

Camb. City	-267	(89)
South Cambs	-30	(99)
East Cambs	-49	(98)
Hunts.	-27	(99)
Average	-93	(96)

Table 7.4 Combined Option 2016: Changes in production cost (£/month/employee) with respect to the Base Case(2016 = 100)

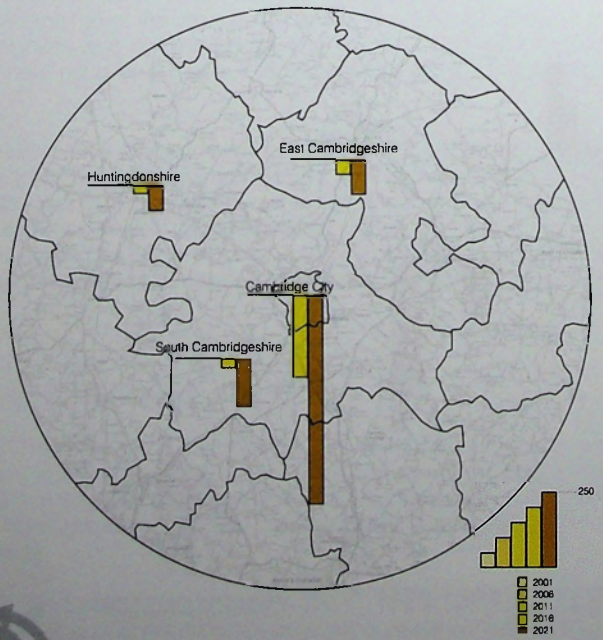


Figure 7.4 Combined Option: Changes in the cost of production over time compared to the Base Case

7.4 Transport impacts

- Car trips into the city reduce by 52% as a consequence of the combined policy option.
- There is an 8% increase of car trips that have both an origin and destination in Cambridge as a consequence of the improvement in driving conditions.
- There is a 31% reduction in traffic delays.
- There is a 40% increase in average speeds to 17 miles per hour in the peak period for the main distributor roads.

Figure 7.5 shows that there are few delays on the main roads in Cambridge as most of the main links of the network are operating within their capacity with less congested links than any of the other options. Congestion charging increases the traffic flows on the orbital highway around the south of Cambridge and it appears that this section would need to be dual carriageway between Hauxton Road (A1309) and Cambridge Road (Fulbourn). Public transport use increases substantially, both in the Sub- region and within Cambridge to similar levels achieved by the Public Transport Option.

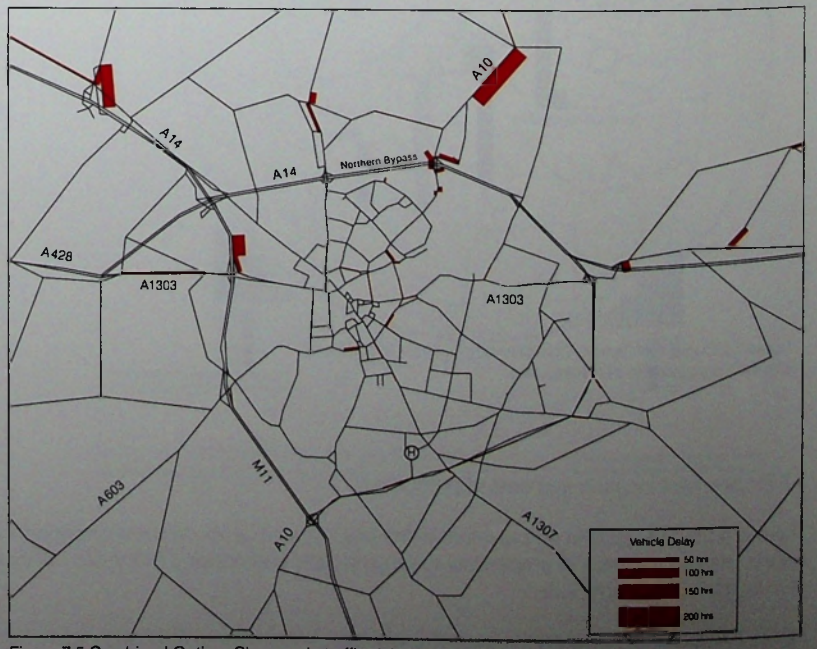


Figure 7.5 Combined Option: Changes in traffic delays

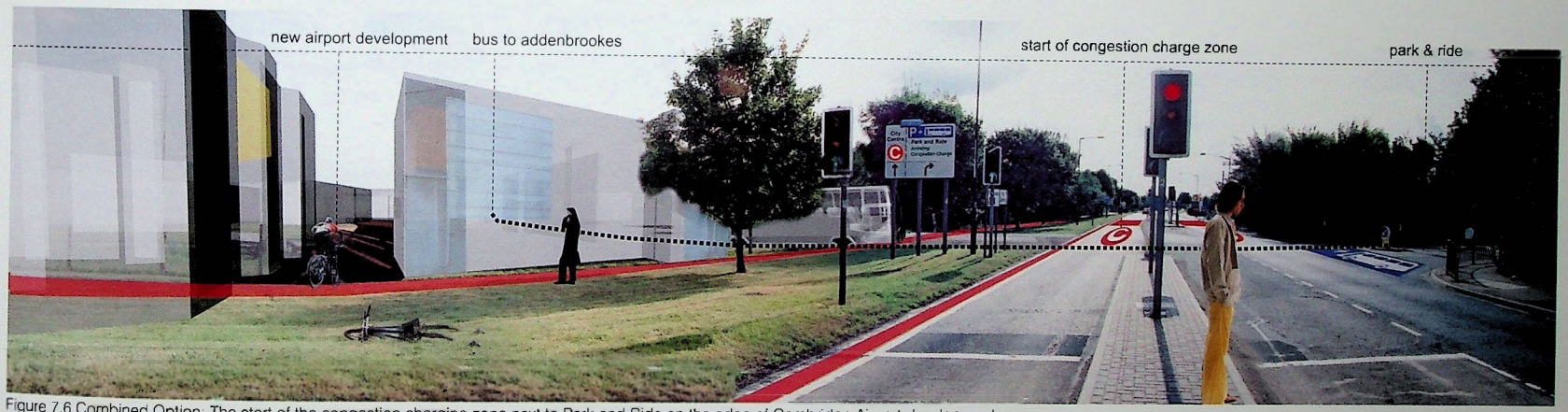


Figure 7.6 Combined Option: The start of the congestion charging zone next to Park and Ride on the edge of Cambridge Airport development

7.5 Feasibility of the Option

Cost of investment

- It is estimated that the overall capital cost of investment would be approximately £539 million. It would include £2 million for cycling paths and pedestrianisation, £405 million invested in public transport, £120 million for the highway improvments (orbital) and £8 million invested in the congestion charging scheme.

Annual benefits

- User annual benefits are -£5.8 million which means a net total cost. It includes the payment of £38.6 million in tolls to the operator. There is an additional saving in transport costs of £5.7 million. Savings in time are evaluated at £28.2 million due to the reduction in congestion in and around the city. There is also a convenience benefit of -£1.1 million (cost) due to the shift from cars to less convenient modes of transport with some impairment to mobility.

- Operator benefits are only estimated for the congestion charging operator. The revenues from the charge are estimated at £ 38.6 million. The cost of operating the system is £ 8.2 million giving an annual benefit of £30.4 million.

Government tax revenue reduces by £1.3 million because of a diminution of fuel consumption.

Rate of return

- The total cost of the Combined Option is estimated at £539 million, and an annual benefit at £23.3 million giving a social rate of return of 4.4% in 2016. (See table 7.5).

Investment Costs	Cycling & Walking	2
Equipment etc.	Public Transport	409.4
	Orbital Highway	120
	Congestion Charging	8
	Total Investment	**539.4**
Annual Benefits	User: tolls	-38.6
	User: cost savings	5.7
	User: time savings	28.2
	User: convenience	-1.1
	User Total Benefits	**-5.8**
	Operator: revenues	38.6
	Operator: costs	-8.2
	Operator Total Benefits	**30.4**
	Government Benefits	**-1.3**
	Total Benefits	**23.3**
Rate of Return %	Social	**4.4%**

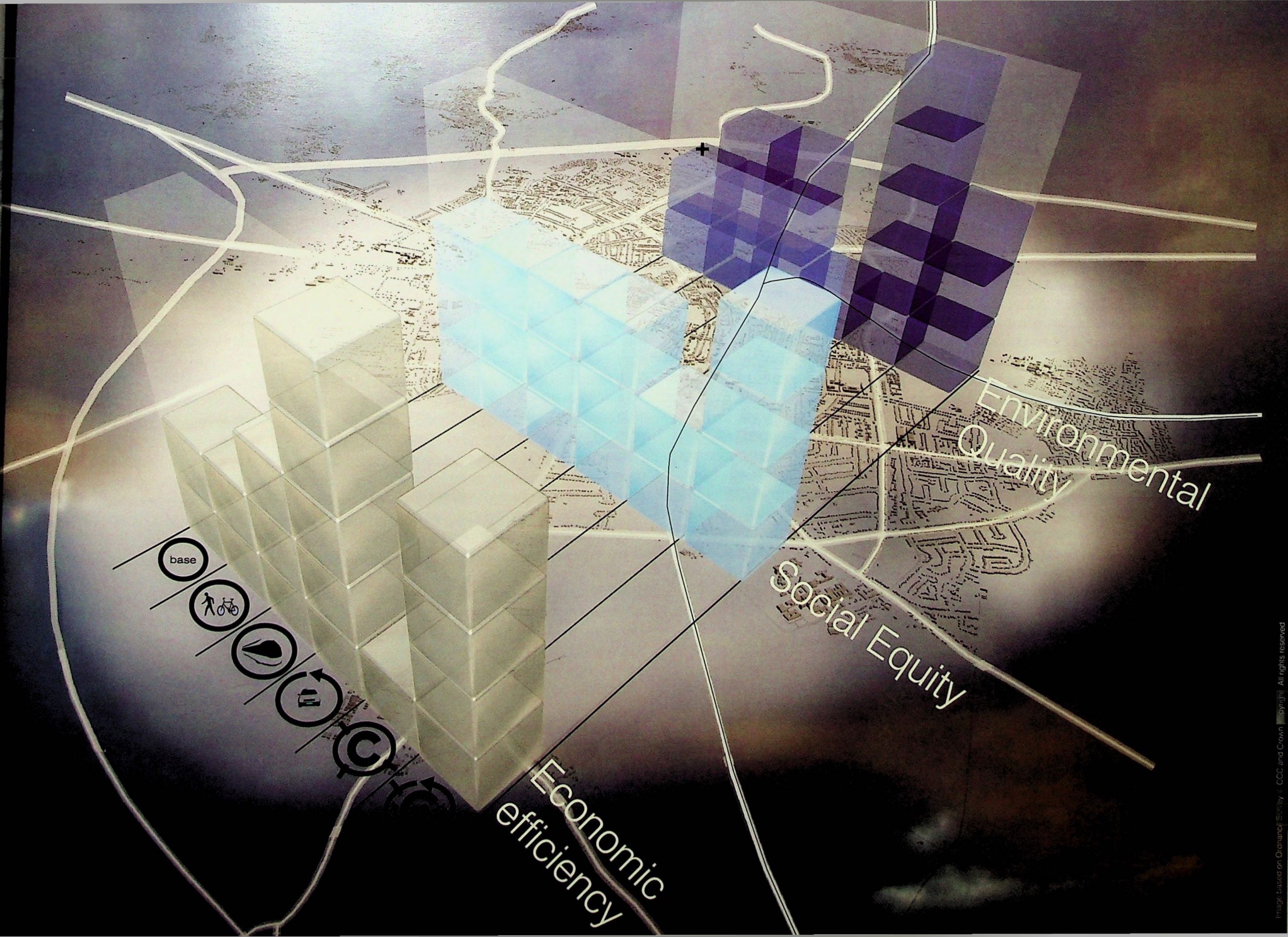
Table 7.5 Combined Option: Summary of economic feasibility

The economic efficiency of the Combined Option is good. The increase in car transport costs due to the congestion charging are offset by a lowering in transport costs due to the improved public transport and the orbital highway. This combination of transport measures would result in a readjustment of land uses with jobs and households moving outside the city, especially to the East Cambs and Huntingdonshire districts that offer cheaper housing, but would now be served by improved transport. There is a 5% overall reduction in the cost of production compared to the Base Case, which would help to maintain the competitiveness of the Sub-region. Exporters would reduce costs by £140 million per year.

From the social point of view, the impact is not significant. Similar mixes of socio-economic groups are located in the city and surrounding districts. There is some reduction of the high income groups in the city, and an increase in the Hunts and East Cambs districts. This change may improve social balance in the future. There is an increase in mobility that offers people a wider choice of transport modes and a reduction in travel time. The public transport element would provide people with an improved alternative to paying the congestion charge. All groups benefit about equally.

From an environmental point of view the combined option is somewhat mixed. There is a reduction in carbon emissions for trips into the city, but this is counteracted by the increase in traffic within and outside Cambridge. Considering all the effects, the carbon emissions do not change significantly from the Base Case. The Combined Option includes the orbital highway, which would have an adverse environmental impact around the south and east of Cambridge, mitigated by tunnels and landscaping, as described in Section 5.6. If the public transport tunnel was affordable, the Combined Option would remove a substantial part of the public transport from the streets and provide the opportunity to improve the urban environment of Cambridge City Centre.

Figure 7.7 Combined Option: From Chesterton looking towards new guided bus and cycle bridge



8 Comparison

8.1 Comparing the feasibility of the options

The attractiveness of cycling and walking needs to be maintained as Cambridge expands. Otherwise, the proportion of journeys made by these modes will decline, with severe consequences for traffic congestion. The costs associated with extending and improving the present cycling and pedestrian network are relatively modest, and measures that successfully encourage more cycling and walking are likely to be economically, socially and environmentally beneficial.

All of the options are technically feasible but much more work needs to be done on the costings of the options to assess their final economic feasibility, particularly for the Public Transport Option. Building a tunnel and two interchanges is a complex issue and requires detailed assessment, outside the scope of Cambridge Futures' present work. It may be possible that the underground interchanges can be developed as part of the re-development project, being considered at the main rail station. It may also be possible to re-develop the present bus station together with the Bradwell Court arcade to achieve an economically attractive development and underground interchange. If the tunnels between the bus station and rail station are not economically viable, it may still be cost effective to include either a tunnel or bridge for a public transport connection between the railway station and east Cambridge, via Davy Road. The second best option for public transport is to build a physically segregated bus lane from the rail station along Station Road and Hills Road to Regent Street. Following the planned expansion of the pedestrian core scheme, the remainder of the route to the bus station is likely to be for buses and access only. However the transport performance in terms of travel time, etc. of the Public Transport Option would be reduced, attracting less passengers. In addition the long term environmental impact would be much greater with the noise, potential accidents, and congestion caused by a continual flow of buses.

The modest social rate of return of less than 1% is unlikely to obtain public funding, but this option has the advantage of providing greater accessibility to people who are unable to travel by car. Public transport improvements are particularly useful as part of the Combined Option, by offering people an improved alternative to driving and paying the congestion charge. The difficulty with public transport is that it does not attract sufficient patronage in a small city like Cambridge to justify a large scale investment. However, the environmental and social benefits can be considerable, but are difficult to quantify in economic terms.

The Orbital Option involves a substantial capital investment particularly if a tunnel is constructed to mitigate the visual impact around the south east of Cambridge. However, even with the extra cost of £80 million for the tunnel, it is still economically feasible.

The first year social rate of return of 12% makes it a strong contender for government funding.

The Congestion Charging Option involves a modest capital cost in equipment, (e.g. cameras, telecommunication, software and computers), of about £8 million. The revenue of about £30 million per year makes the scheme economically plausible. The revenue estimated by 2016 takes into account a reduction of profits from the first year of operation (estimated at £42 million) as households and jobs re-locate to avoid paying the charges. The cost of operation of the congestion charging scheme includes the management and maintenance of the system (e.g. charging, monitoring, and collecting money owed, etc.) is estimated at £8 million per year. From the private point of view the rate of return in 2016 is over 400%. This is the ratio between the net annual revenue, after discounting the operational costs and the capital invested. Using conventional appraisal, the policy does appear to be socially profitable.

The annual benefits are estimated at £6.9 million, giving a social rate of return of over 80%. However, drivers and businesses would be £20 million worse off per annum. Further tests with a reduced charge could be carried out, but this would also reduce revenues and environmental benefits. It is probable that optimum pricing would include a higher internal charge to avoid extra traffic within Cambridge and a lower cordon charge for people entering the City. In conclusion, the Congestion Charging Option needs to be combined with other measures, such as improving public transport and highways, to achieve a satisfactory results for transport users, illustrated by the Combined Option.

The Combined Option includes the elements of all the previous options. The investment costs are high, estimated at £539 million, but the net total benefits are around £23 million per annum, giving a 4% rate of return on the investment. Users of the transport system are worse off by £6 million per year, as they would be paying tolls but also compensated by savings in travel time and other costs. The Combined Option would enable the necessary funds to be raised to implement part of the component schemes.

Table 8.1 summarises the economic appraisal of each of the options. The Cycling and Walking Option was not assessed in isolation, as benefits in economic terms are difficult to estimate. The Public Transport Option gives a poor rate of return as the cost are high and the benefits are low. The orbital highway gives a substantial social return on the investment. The Congestion Charging Option gives a high return on the investment, but penalises the users of the transport system. The Combined Options gives a satisfactory social rate of return that may be acceptable for public investment. A fine tuning of the Combined Option would probably eliminate the overall negative benefits for users of the transport system.

Item	sub-item	Cycling Walking	Public Transport	Orbital Highway	Congestion Charging	Combined Option
Investment Costs	**Total Costs**	**2**	**409**	**120**	**8**	**539**
Annual Benefits	User: tolls		-	-	-41.4	-38.6
	User: cost savings		1.4	1.1	3.3	5.7
	User: time savings		2.6	6.4	20.6	28.2
	User: convenience		-1.6	6	-6.1	-1.1
	User Total Benefits		**2.4**	**13.5**	**-23.6**	**-5.8**
	Operator Total Benefits		**-**	**-**	**33.3**	**30.4**
	Government Benefits		**-0.1**	**1.3**	**-2.8**	**-1.3**
	Total Benefits		**2.3**	**14.8**	**6.9**	**23.3**
Rate of Return %	Social	**-**	**<1%**	**12%**	**86%**	**4%**

Table 8.1 Comparison: Economic feasibility of the options (cost-benefit analysis) £ millions / %

8.2 Comparing the sustainability of the options

The comparison takes the Structure Plan as the Base Case, so all the results are relative to that case. The sustainability of the options is judged in terms of economic efficiency, social equity and environmental protection, although Cambridge Futures has made no attempt to assert any preference for any particular option.

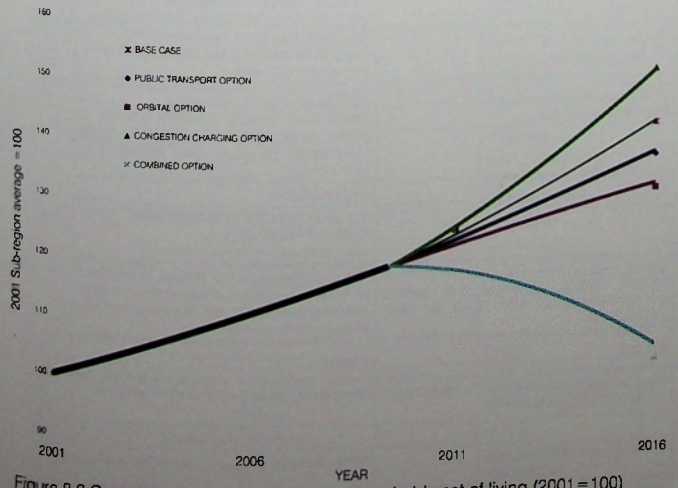


Figure 8.2 Comparison: Change in average household cost of living (2001=100)

The economic efficiency is judged in terms of changes in the cost of living and production costs. If costs increase, households would suffer, especially those with relatively fixed income such as retired and unemployed groups. Working households would put pressure on employers to receive higher salaries and companies would then raise prices. The firms who export goods and services out of the Sub-region would suffer if cost increased. This may result in a reduction in their share of the global market if these costs are passed on to customers who may not be willing to pay the extra.

Figure 8.2 illustrates the changes for each option in the cost of living for average households. It can be seen that the Combined Option considerably reduces the cost of living in the Sub-region. Figure 8.3 illustrates the changes for each option in average production costs. It can be seen that the Orbital Option would result in the lowest production cost increases, followed by the Combined Option and the Public Transport Option. The Congestion Charging Option would increase the costs, above that of the Base case. Actual monetary savings for the export sector of the economy are illustrated in table 8.2. It can be observed that the Orbital Option and the Combined Option would substantially reduce production costs, increasing economic efficiency, thereby encouraging economic growth in the Sub-region.

	Public Transport	Orbital highway	Congestion charging	Combined option
Exporting employers cost savings	90	175	-160	140

Table 8.2 Comparisons: Savings in annual production cost for employers in export firms (£ millions) 2016

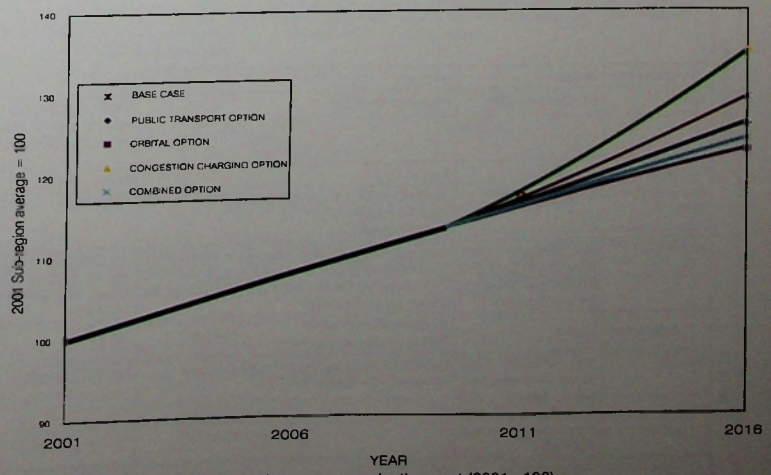


Figure 8.3 Comparison: Change in average production cost (2001=100)

Table 8.3 APPRAISAL SUMMARY TABLE: COMPARISON BETWEEN THE OPTIONS AND THE BASE CASE FOR YEAR 2016

Objectives		Cycling and Walking	Public Transport	Highways	Congestion Charging	Combined
ENVIRONMENT	Noise	Reduction not significant	Reduction due to less traffic not significant. Using hybrid diesel/electric vehicles would mitigate noise from the public transport system.	Slight reduction on some roads in Cambridge. Major increase for properties near the orbital road around the south and east of Cambridge.	Major reduction on busy roads in Cambridge. Slight increase on some orbital routes around the south east of Cambridge.	Significant reduction on busy roads in Cambridge. Major increase for properties near the orbital road around the south and east of Cambridge.
	Assessment	Neutral	Slightly positive with main tunnel Slightly negative without tunnel	Negative	Positive	Slightly negative
	Local air quality	Reduction not significant	Overall reduction not significant. Using hybrid diesel/electric would reduce air pollution from buses in the city centre. Without a tunnel there would be an increase in city centre congestion	Improvement along routes in south east Cambridge used by circulating traffic. Slight worsening for some properties near the orbital road.	Major improvement for some areas in Cambridge.	Major improvement for some areas in Cambridge. Slight worsening for some properties near the orbital.
	Assessment	Neutral	Slightly positive with main tunnel Slightly negative without tunnel	Neutral	Positive	Slightly positive
	Greenhouse gases	Slightly positive	Neutral	Negative	Positive	Neutral
	Landscape	Insignificant impacts	Minimal intrusion – slight impact on Ditton Meadows	Impact of orbital mitigated by tunnels and landscaping.	No effect	Impact of orbital mitigated by tunnels and landscaping
	Assessment	Neutral	Neutral	Negative	Neutral	Negative
	Townscape	Improvements	Opportunity to improve townscape if tunnels are included. Some detriment to Milton Road due to widening.	No significant effect.	Opportunity to improve townscape if road-space is reallocated for other uses.	See the comments for each individual option
	Assessment	Slightly positive	Slightly positive with main tunnel Slightly negative without tunnel	Neutral	Slightly positive	Positive
	Heritage of historic resources	No effect.	No effect.	Orbital crosses Wort's Causeway (Roman Road and Fleam Dyke – archaeological excavations required before construction	No effect.	Orbital crosses Wort's Causeway (Roman Road and Fleam Dyke – archaeological excavations required before construction
	Assessment	Neutral	Neutral	Slightly negative	Neutral	Slightly negative
ENVIRONMENT	Biodiversity	No significant effect	No significant effect.	An ecological survey has not been carried out. The proposed highways are not expected to cross any areas of national ecological significance. The orbital road could include sensitively designed landscaping and balancing ponds to encourage biodiversity.	No significant effect.	An ecological survey has not been carried out. The proposed highways and public transport routes are not expected to cross any areas of national ecological significance. The orbital road could include sensitively designed landscaping and balancing ponds to encourage biodiversity.
	Assessment	Neutral	Neutral	Neutral	Neutral	Neutral
	Water	No significant effect	No significant effect	Orbital road crosses Hobson's conduit, a ground water protection area, and would need careful design to avoid contamination from run-off.	No effect	Orbital road crosses Hobson's conduit, a ground water protection area, and would need careful design to avoid contamination from run-off
	Assessment	Neutral	Neutral	Slightly negative	Neutral	Slightly negative
	OVERALL EFFECT	SLIGHTLY POSITIVE	SLIGHTLY POSITIVE (with main tunnel) SLIGHTLY NEGATIVE (without tunnel)	NEGATIVE	POSITIVE	SLIGHTLY POSITIVE (with main tunnel) SLIGHTLY NEGATIVE (without tunnel)
SAFETY	Accidents	Not assessed. Not likely to be significant providing the schemes are well designed.	Increased use of public transport is expected to improve safety overall, but there may be a worsening of road safety in the city centre, given that tunnels are likely to be unaffordable.	Not assessed. New roads are generally safer than existing roads, so although drivers will be travelling further, the overall effect on safety is expected to be neutral.	Overall reduction in traffic would generally improve safety, providing that speeds are constrained to safe levels by traffic management.	The combination of the options is expected to result in an overall improvement in safety, providing that speeds are constrained to safe levels by traffic management.
	Assessment	Neutral	Positive with main tunnel Slightly positive without tunnel	Neutral	Positive	Positive
	Security	The schemes need to be well designed, with lighting and preferably overlooked by properties or near highways.	Public transport interchanges need to be well designed, with lighting and CCTV.	No significant effect	More people would switch from car to public transport, cycling and walking.	See the comments for each individual option
	Assessment	Slightly negative	Slightly negative	Neutral	Slightly negative	Slightly negative
	OVERALL EFFECT	SLIGHTLY NEGATIVE	SLIGHTLY POSITIVE (with main tunnel) NEUTRAL (without tunnel)	NEUTRAL	SLIGHTLY POSITIVE	SLIGHTLY POSITIVE

Table 8.3 continuation

ECONOMIC	Transport economic efficiency	Improves transport efficiency by allowing mobility without significantly adding to congestion.	With a bus-tunnel between the railway station and Victoria Avenue the Social Rate of Return is only 0.6%. Without this tunnel, (but still having a tunnel under the railway), the Social Rate of Return would be less than 4% depending on the amount of congestion.	12% Social Rate of Return	86% Social Rate of Return	With a bus-tunnel between the railway station and Victoria Avenue the Social Rate of Return is 4%. Without this tunnel, (but still having a tunnel under the railway), the Social Rate of Return would be almost 12%.
	Assessment	Slightly positive	Neutral	Positive	Positive	Neutral with main tunnel Positive without tunnel
	Journey time reliability	Journeys on foot and by cycle usually have reliable journey times. Journeys by car may be slightly more reliable.	improvements to public transport should improve journey time reliability by all modes providing that congestion in the central area can be solved.	Highway improvements would improve journey time reliability by car. Less congestion in the city centre would also improve public transport reliability.	Car journeys in Cambridge would be much more reliable for people willing to pay the charge. Less congestion in the city centre would also improve public transport reliability.	See the comments for each individual option
	Assessment	Slightly positive	Positive with main tunnel Slightly positive without tunnel	Positive	Positive	Positive
	Wider economic impact (This has been given more weight than the other economic criteria when assessing the overall effect)	Not significant	For the Sub-Region: Productions costs down 3% Cost of living down 4% For Cambridge: Production costs down 6% Cost of living down 8% (Benefits may be less without a main tunnel)	For the Sub-Region: Productions costs down 5% Cost of living down 8% For Cambridge: Production costs down 1% Cost of living down 17%	For the Sub-Region: Productions costs up 5% Cost of living up 6% For Cambridge: Production costs up 11% Cost of living up 9%	For the Sub-Region: Productions costs down 4% Cost of living down 20% For Cambridge: Production costs down 11% Cost of living down 28%
	Assessment	Neutral	Slightly positive	Positive	Negative	Positive
	OVERALL EFFECT	NEUTRAL	SLIGHTLY POSITIVE	POSITIVE	SLIGHTLY NEGATIVE	POSITIVE
SOCIAL ACCESSIBILITY	Option values	Not significant	Some areas will have improved public transport.	Improved access to park and ride sites. Improved access by road for orbital movements around south-east Cambridge.	Not significant	More choice of modes available
	Assessment	Neutral	Positive	Positive	Neutral	Positive
	Access to the transport system	Improved access by cycle and on foot	Some areas will have improved public transport	Not significant	People on low incomes would find it difficult to afford to congestion charge.	See the comments for each individual option
	Assessment	Positive	Positive	Neutral	Negative	Slightly positive
	Severance	Cycling and walking facilities should reduce severance.	Severance could get worse in the city centre due to bus congestion, unless there is a tunnel between the bus and rail stations.	The orbital road would result in some severance of existing rights of way but these would be replaced with alternatives wherever possible.	Less traffic within Cambridge would reduce the severance effect of busy roads.	See the comments for each individual option.
	Assessment	Slightly positive	Slightly positive with tunnel Slightly negative without tunnel	Slightly negative	Positive	Slightly positive
	OVERALL EFFECT	POSITIVE	POSITIVE (with main tunnel) SLIGHTLY POSITIVE (without tunnel)	SLIGHTLY POSITIVE	NEUTRAL	POSITIVE
SOCIAL EQUITY		NEUTRAL	NEUTRAL	NEUTRAL	SLIGHTLY NEGATIVE	SLIGHTLY POSITIVE
INTEGRATION	Land use policy	Consistent with land use policies in the Structure Plan	The public transport proposals would support the land use policies of the Structure Plan	The orbital highway could increase pressure for further peripheral development around Cambridge and in rural areas	Likely to increase pressures for development in rural areas around Cambridge	May allow a balance to be achieved consistent with the Structure Plan if the congestion-charging element is optimised.
	Assessment	Positive	Positive	Negative	Negative	Neutral
	Other Government polices	Consistent with policies in the health, education and social sectors	Consistent with policies in the health, education and social sectors	Consistent on the basis that the demand for orbital movement cannot effectively be met by public transport and non-car modes.	Consistent with policies in the health, education and social sectors	See the comments for each individual option
	Assessment	Positive	Positive	Neutral	Slightly positive	Positive
	Transport interchange	No significant effect	Improvements proposed to bus and rail interchanges	Improved access to park and ride sites	No significant effect	See the comments for each individual option.
	Assessment	Neutral	Positive	Slightly positive	Neutral	Positive
	OVERALL EFFECT	POSITIVE	POSITIVE	SLIGHTLY NEGATIVE	SLIGHTLY NEGATIVE	POSITIVE

Social equity can be assessed by looking at how different socio-economic groups would be affected by each option.

The Public Transport Option benefits a higher proportion of SEG1: professional and managerial group. This is probably due to a combination of factors such as the reduction in traffic delays as more people switch to public transport reducing travel times for car users and improving the speed of long distance commuting.

The variations in social mix are small and the options would not significantly change the social composition of each district, compared to the Base Case.

The environmental impacts can be judged in terms of a combination of objective and subjective aspects. The objective aspects can include emissions, especially carbon dioxide, noise impacts and safety. The more subjective aspects would include visual intrusion and quality of the environment.
Table 8.3 summarizes the appraisal of the options.

8.3 Implementation

There are a number of potential sources of funding for transport schemes, including developer's contributions, public funding, charging users and possibly in the future a land tax. The following example explains how revenue raised form the congestion charge could be used for funding the options.

To improve transport in the Sub-region it may be necessary to create an Agency that could collect charges and run the transport system. The purpose of the agency would be to implement the transport infrastructure investment by raising the necessary funds, awarding building contracts, collecting revenues, subsidising some of the operators, etc. The agency could be set up in a similar way to Transport for London, (e.g. Transport for Cambridge).

There could be three types of agency, each adapted for a different purpose:

(i) Public Agency. Made up of local and national authorities.
(ii) Public-Private Agency. Made up of public authority (80%) and private stakeholders (20%) that have particular interest in improving the system (e.g. large employers)
(iii) Private concessionaire that would run under contract from the public authorities a limited period concession.

The responsibility for fixing the charges would remain under the control of the authorities, but the operation would be the responsibility of the agency.

It has been calculated that such an agency could raise part of the funding for the options in financial markets. Table 8.6 illustrates the probable funding that could be obtained given the concession period. At present the Treasury allows 10 year hypothecation of the charging revenues. If that period were extended, the raising of the amount of capital in the market could be increased.

Table 8.6 illustrates the maximum amount of funding that can be raised depending on whether the congestion charges are levied in the peak period or only during the day (i.e. 7am to 6.30pm), and the type of Agency created. It assumes that the money is raised in the open market.

Within the current rules, only revenues for 10 years can be used for local investment. Depending on the type of Agency created and the period of charging, the amount of funding that can be obtained ranges from £120 million to £195 million. The risk premium required by private investors is lower, and public agencies are not taxed, giving the latter the advantage, but private concessionaries can be more efficient in implementing and operating the system.

Within the present rules, and charging only during the peak period, it may be possible to fund a reduced Combined Option, including: Cycling and Walking Option, a much reduced Public Transport Option (e.g. no tunnel between the railway station and the present bus station, but a short tunnel connecting the east of Cambridge, under the railway station), and an orbital without a tunnel. If the congestion charges are levied for an extended period, the revenues obtained can probably fund the orbital tunnel as well.

A combination of direct public funding, (from taxation as some of the projects are socially profitable), and open market funding (for the environmental improvements), would be necessary for implementing the Combined Option.

Hypothecation Period	10 years		20 years		27 years	
Agency	Peak	Day	Peak	Day	Peak	Day
Public	125	195	195	300	225	350
Public-Private	130	190	185	270	205	300
Private	120	180	172	250	185	275

N.B. The following financial parameters are assumed: Debt service cover ratio of 1.1 for a public agency to 1.4 for a private concessionaire; risk premium for private investor 5-7 % over UK Government bond (4.5% yield); 6.5 % debt interest; 30% corporation tax.

Table 8.6 Comparison: Maximum funding in £ millions that can be raised for implementing the transport options, given congestion charging revenues.

8.4 Conclusions

Cambridge Futures has assessed the likely impacts in the Cambridge Sub-region of the 2003 Cambridgeshire Structure Plan. It has concluded that the Structure Plan makes a substantial contribution towards the economic, social and environmental sustainability of the area. By allowing an expansion of the city in selected areas of the green belt and a new settlement, economic and social development will improve and if the expansion areas are well designed, the environmental quality of the Sub-region would be preserved.

The results obtained by Cambridge Futures indicate that the expansion of the built up areas of the City and the overall Sub-regional growth would produce more congestion. This is despite the introduction of transport improvements to the A14 trunk road and the implementation of HQPT linking Huntingdon with Cambridge. The increase in congestion would risk the continuation of the Cambridge's success.

To reduce the transport problems, Cambridge Futures has investigated four options in isolation and one in combination.

The first option – Cycling and Walking – has not been assessed separately, but is clearly useful and should be considered in any case.

The second option – Public Transport – produces results that are positive in terms of sustainability. However, the cost of implementing the option is too large for the modest benefits obtained. This option is unlikely to be feasible on it's own, and thus a reduced investment should be explored. Improving public transport would not be sufficient to attract passengers from cars in large enough numbers to make this option viable.

The third option – Orbital Highway – produces substantial benefits in terms of savings in money, time and inconvenience. It would probably be fundable under economic criteria. The environmental impact can be mitigated by the construction of a tunnel, which would reduce the visual impact in a sensitive landscape area of the south east of Cambridge.

The fourth option – Congestion Charging, although financially and technically possible, does not benefit passengers in terms of money It does have benefits in terms of time savings, as well as a better impact on the environment than the Orbital, reducing congestion and therefore carbon emission. The overall user benefits are negative demonstrating that the option on its own would not be attractive and would therefore encounter resistance from the public.

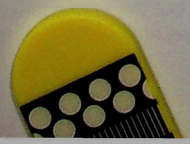
The Combined Option generates positive economic as well as environmental benefits. It can, in theory, partially fund the investment cost of the expansion of public transport and the Orbital Highway, but this would depend on the length of time that the revenues for congestion charging are kept by the local authorities.

Table 8.7 summarises the sustainability for all of the options. All of them score equally or higher than the Base Case, except for the Congestion Charging Option, which scores highly in terms of environmental protection, but poorly economically and the Orbital Option, which scores less on environmental quality.

It is clear that further transport improvements will be needed in the Cambridge Sub-region beyond those already committed if the anticipated rates of local economic growth are to be sustained. It is hoped that this report helps the public and decision makers to understand what the foreseeable consequences would be of different transport policy directions, which will inform the debate about what transport policy is appropriate for Cambridge for the future.

Options	Economic Efficiency	Social Equity	Environmental Quality
Base Case: Structure Plan	**	***	**
Cycling & Walking	**	***	***
Public Transport	***	***	***
Orbital Highway	*****	***	*
Congestion Charging	*	**	*****
Combined Option	****	****	***

Table 8.7 Comparison: Sustainability of the options (* low - high*****)



Appendix A: Technical Issues

Land use and transportation models

Cambridge Futures has made use of two types of computer model hosted by Cambridgeshire County Council for estimating the likely market responses to the policy options: the MENTOR land use model developed by ME&P and the SATURN highway model developed by W S Atkins.

MENTOR is a Windows ® based land use model. Although it is based on an innovative new software product, the model uses tried and tested techniques originally developed as part of the MEPLAN[1] modelling framework. It has been designed to use standard census data for the UK and to accept measures of accessibility from transport models. It requires study-area-wide inputs to start the process (i.e. forecast of overall levels of employment and households for the region) and the allocation of dwellings and commercial floorspace to zones within the area (this represents the policies to be tested).

Given the inputs stated above, the model finds an equilibrium between the demand for location by firms and households and the supply of buildings in each location. The equilibrium gives a price (or rent) for dwellings and floorspace. The factors which MENTOR takes into account for the location of households are as follows:

- Supply of dwellings in each zone
- Cost of living in each zone (including housing, transport, goods, services, taxes, etc.)
- Accessibility to employment of each zone (if any member of the household is in employment)
- Attractiveness of each zone (i.e. all non-economic factors which are estimated as an index in the calibration year representing environmental qualities of the zone)

The factors which MENTOR takes into account for the location of firms are as follows:

- Supply of floorspace in each zone
- Cost of production in each zone (including cost of floorspace, transport costs incurred by suppliers, cost of labour, taxes, etc)
- Accessibility to customers' location from each zone
- Attractiveness of each zone (i.e. all non-economic factors which are estimated as an index in the calibration year representing environmental qualities of the zone)

Output from the model in any particular time period covers the location of households and firms, the price paid for dwellings and floorspace in each zone and the transport flows between zones (e.g. journeys to work, to school, to shops, etc). Transport flows are input to a transport mode which estimates the likelihood of a journey being made by various means (mode of transport).

The transport model takes into account the following factors to determine the mode of transport:

- Modes available to the traveller
- Generalised cost of transport by each mode. This includes time for waiting, travelling, etc, and the monetary cost of the journey, such as fares, petrol prices and parking costs
- The convenience of each mode of travel (i.e. non-economic factors which are estimated as an index in the calibration year representing comfort and other qualitative factors)

The output of the multi-modal transport model is input into the highway assignment model SATURN, developed by W S Atkins for Cambridgeshire County Council. SATURN assigns the vehicular traffic to individual roads and calculates delays at junctions due to congestion. MENTOR model has been used for testing the 2003 Cambridgeshire Structure Plan and the Cambridge to Huntingdon Multi-Modal Study (CHUMMS).

Calibration of MENTOR

The MENTOR model was calibrated (i.e. all parameters governing the relationship between the factors modelled) using the 1991 Census. It includes the following classification of firms and households:

Seven categories of organisations which employ labour from different socio-economic groups:

- Primary (agriculture and extractive industries)
- Secondary (manufacturing)
- Tertiary (high tech businesses services and higher education)
- Retail
- Education
- Private services (finance, recreation, professional, etc)
- Public services (health, government, etc)

Thirty categories of household combining

- Socio-economic groups (managerial and professional, clerical and adminstrative, manual and unskilled)
- Car ownership groups (no car, one car, two or more cars)
- Size (one adult or two-plus adults)
- Participation in the labour market (in an occupation, unemployed and retired)

The relationship between the seven categories of firm and the thirty categories of household is established in the calibration year but the relationship changes through time, depending on the growth or declines of firms and the cost of employing different types of labour.

In addition the model relates firms and households to four types of buildings (industrial, office, retail and residential). The results of the model in any particular time period give the monthly rental of the buildings in each location. The model thus reacts to policy changes by producing new rental levels in each zone which in turn affect the cost of living for households and the cost of production for firms. These costs influence the location of households and firms, altering trip patterns, and affecting congestion on the roads.

MENTOR outputs reproduced the valued of the 1991 Census and produced a reasonable estimate of rental levels for each zone in the study area.

The study area has been divided into sixty-seven internal zones, corresponding to wards in Cambridge and the surrounding districts. In addition there are ten external zones which represent districts within twenty-five miles of the City of Cambridge (e.g. in Suffolk, Essex, Hertfordshire, Bedfordshire, Peterborough and Fenland), London and the rest of the South East.

The Cambridge MEPLAN Transport Model provides the multi-modal modelling element of the Cambridge Futures Study. The model is a detailed transport model that covers the Cambridge Sub-region. The model is capable of examining public transport modes as well as highway traffic assignment. With the ability to produce and assign matrices (the data associated with origin to destination movements), the model is an ideal partner to the land use modelling undertaken by MENTOR.

A SATURN transport model has been developed by Cambridgeshire County Council since 1986 and has been comprehensively revised and updated to reflect currently day conditions. Separate models exist for morning and evening peaks together with a representative off peak hour.

The model uses the SATURN suite of programs, a proprietary traffic model developed by Atkins. The network is split into a rural area, where traffic loadings relative to the road capacity determine the appropriate speed on the link, and the simulation area, where individual junctions are modelled. In the simulation, delays are calculated based on the interaction of traffic at priority, roundabout or traffic signal control junctions.

The validity of the model is checked by comparing traffic flows predicted by the model against observed traffic counts conducted in the area covered by the model. The counts conducted annually (such as the counts on all routes entering Cambridge City) provide a good source of data, as changes through time can be readily identified.

The model has been used extensively by the County Council to test the impact of measures such as:

- Street closures
- Major developments
- Road pricing and
- Public transport initiatives
- Guided bus
- St. Ives Heavy Rail

With up-to-date detailed planning data supplied by local authorities and growth factors based on information supplied by the Department of Transport, Environment and the Regions (DETR), the model has been used to forecast the impact of these measures.

(Footnotes)

[1] MEPLAN is a software developed by ME&P which has been used for modelling London, Helsinki, Bilbao, Naples, etc. Further references for the equations system and calibration procedures can be found in: Research into Practice: the Work of the Martin Centre in Urban and Regional Modelling. Eds. M. Echenique and J. Owers. Special issue of Environment and Planning B: Planning and Design, Vol. 21 (5) pages 513-650, 1994

Urban Land Use and Transport Interaction, eds. F. V. Webster, P.J. Bly and N. J. Paulley. Gower Aidershot, 1988

'Testing Integrated Transport and Land Use models in the Helsinki Metropolitan area', M. Echenique, P. Moilanen, K. Lautso and H. Lahelma, Traffic Engineering & Control, Vol. 36, No. 1, pp 20-23, 1995

Assumptions

- Deposit Draft Structure Plan is taken as the basis for this study and its policies such as housing targets and business floorspace plans are incorporated into the Base Case (see tables A1 and A2) - without judgement on their efficacy. The Deposit Draft has since been subject to an examination in Public and Consultations on the Panel Report[32]. The revisions to the Deposit Draft do not have a significant effect on the assumptions for this study. Hence, the Base Case represents the most likely land use scenario to become reality. Only the committed transport schemes are included. Amongst the uncommitted schemes, is a rapid transit between the proposed redevelopment of the airport to the east of the city and the city centre. This transport scheme is at an early stage of planning and does not yet have approval. A HQPT route between the airport and City centre, (via the railway station), is tested as part of the Public Transport Option.

- Beyond 2016 a number of assumptions have been made about land use as illustrated in table A3.

- Modelling: assumes that no other local or national policies other than the Draft Structure Plan affect outcomes.

- Orbital Option: assumes that the Base Case includes improvement to the A14/M11 junction (M11 junction 14). Current assumptions in the Cambridgeshire County Council for A14 traffic flows and the growth of through traffic have been taken as correct. Traffic flows on the Orbital depend on the level of service provided by highway design. It has been designed to accommodate peak hour demand but with at grade junctions except where it joins Newmarket Road (A1303) and A14.

- The modelling of the Orbital highway does not take into account traffic potentially backing-up onton the A14 or M11 and reducing trunk road capacity as a result of traffic constraints within Cambridge. The link road concept (section 5.2), to separate local and long distance traffic has not been modelled or costed.

- Capital costs do not include the cost of land.

- There are no constraints on the amount of parking because, according to Cambridgeshire County Council there is surplus capacity. The model includes an average £2.70 per day parking charge for central Cambridge and £1.35 for the outer urban area.

- The model costs are all based on 1991 prices. All proposals (especially tunnelling costs and similar) would need further, more detailed, appraisal. The assessment is presented in 2003, using the retail price index to transform 1991 to 2003 prices.

- Combined Option: Drivers from within the cordon are allowed to exit and re-enter as part of a single journey without charge in order to utilise the orbital road. All car trips into the centre of Cambridge are charged £3.50 per day (2003 prices).

Table A1: Draft Structure Plan Dwellings by zone assumed for Base Case

	TOTAL	2001-2006	2006-2011	2011-2016	Notes
CAMBRIDGE URBAN AREA & GREEN BELT					
2 Trumpington	2740	740	1400	600	
4 Castle	1250		250	1000	
8 E Chesterton	1830	300	830	700	
10 Abbey	2250			2250	Airport site
11 Romsey	320	100	220		
14 Cherry Hinton	800	280	520		
17 Shelford	120	120			
37 Histon	900	400	500		CNF West
40 Teversham	1500	250	500	750	
MARKET TOWNS & VILLAGES					
72 Chatteris	500			500 1000-1170	In-commuting Lower-upper value
49 Ely	500			500	
58 Huntingdon	1000		500	500	From Ramsey alloc.
66 St Neots	1500		750	750	
Rural Centres see below	500		500		
NEW SETTLEMENT					
34 Longstanton	6000		2500	3500	
39 Waterbeach					
COUNTY TOTAL	**21710**	**2190**	**8470**	**11050**	
OUT-OF-COUNTY MARKET TOWNS					
Royston In-commuting	700		470 940-1100	230 460-538	
Saffron Walden In-commuting	200		135 270-316	65 130-152	
Haverhill In-commuting	100		65 130-152	35 70-82	
Newmarket In-commuting	200		130 260-304	70 140-164	
SUB-REGION TOTAL	**22910**	**2190**	**9270**	**11450**	

Rural Centres

Shelford	17,	Sawston	18,	Melbourn	25,
Girton	31,	Swavesey	35,	Histon	37,
Milton	38,	Waterbeach	39,	Fulbourn	41,
Linton	42	Bottisham	44		

Table A2 Draft Structure Plan Business floorspace (wards) assumed for Base Case

Scenario Level 2006			
	Industrial	Office	Retail
2006 @ 33%			
Newnham 3		7500	
Bourn 33		18167	1500
Swavesey 35		6000	
Longstanton 34		2667	
Waterbeach 39		13800	
Ickleton 22		7667	
Trumpington 2		23000	
Milton 38		21667	
Stukeleys 56	29000	5333	
Abington 16		7667	
Zone Total 2006	29000	113468	1500
SAW total 01-16	-11110	360000	82103
Saw 2006 @ 33%	-3703	120000	27368
SAW balance			
2006 @ 33%	-32703	6532	25868
	New/revised floorspace adjustment		

Scenario Level 2011			
	Industrial	Office	Retail
Zone 2011 @ 33%			
Newnham 3		7500	
Bourn 33		18167	1500
Swavesey 35		4000	
Longstanton 34		2667	
Waterbeach 39		9200	
Ickleton 22		7667	
Trumpington 2		23000	
Milton 38		21667	
Stukeleys 56	29000	5333	
Abington 16		7667	
New Settlement 2011 @50%	22688	12375	6188
Zone Total 2011	51688	119243	7688
SAW			
Saw 2011 @ 33%	-3703	120000	27368
SAW balance			
2011	-55391	757	19680

Scenario Level 2016			
	Industrial	Office	Retail
Zone 2016 @33%			
Newnham 3		7500	
Bourn 33		18167	1500
Swavesey 35		0	
Longstanton 34		2667	
Waterbeach 39		0	
Teversham	-44000		
Ickleton 22		7667	
Trumpington 2		23000	
Milton 38		21667	
Stukeleys 56	73000	5333	
Abington 16		7667	
Abbey	9400	5490	3375
New Settlement 2016 @50%	22688	12375	6188
Zone Total 2016	61088	111533	11063
SAW			
Saw 2016 @ 33%	-3703	120000	27368
SAW balance			
2016	-64791	8467	16305
			Floorspace adjustment as SP tests

* Both business parks are already part completed by 2001. Therefore, 60% zonal floorspace is assumed to be added by 2006 & 40% between 2006-11. Teversham industrial floorspace reduction is from Cambridge Airport. Same amount added to Stukeleys for relocation of Airport to Alconbury. Abbey increase in floorspace is for new development at Cambridge Airport site.

Limitations

- Modelling Generally: is based on the aggregation of individual behaviour and averaged factors. Whilst the overall outcomes are thus modelled in a sophisticated manner, the model sometimes cannot be dis-aggregated to reveal detailed statistics. For instance it uses an average cost for urban parking but cannot determine which commuters use public car parks and which private parking.

- Cycling & walking: Although the computer models include cycling and walking as modes of travel and output detailed results, there are no mechanisms in the model to measure the effects of seasonal, weather, night time security and other fluctuating human response factors on the take up of these modes. The model does not contain a detailed representation of the cycling and walking network and cannot assess the effect of changes to cycling and walking facilities. However, the model does show how changing the attractiveness of other modes affects the numbers of cycling and walking trips.

- Investigations not pursued: There are inevitably many variations around the themes too numerous to include in the study, such as car sharing schemes, or the impact of development taxes. In some cases interpolation between the published options can give an insight into potential outcomes, otherwise they should be the subject of further investigations.

- Publication of Results: the modelling produces an enormous amount of data which then has to be interrogated and analysed, allowing for a multitude of combinations of information. Only the key statistics in categories of general interest and making meaningful comparisons of the outcomes of each option have been reported. There is not space to publish all the figures, but they have been recorded & utilised by the team.

- Table A3 shows the assumptions made prior to the examination in public of the Draft Structure Plan about development beyond the Structure Plan period. This gives a suitable basis for testing the effect of the options, but some of the figure in the table may now be out of date.

Table A3: Assumptions beyond the Structure Plan period 2016 - 2021

Dwellings	The same rate of increase at 2800 dwellings per year is assumed in the Cambridge Sub-region from 2016 to 2021.	
	The new settlement at Longstanton/Oakington is assumed to expand from 6000 dwellings to 9000 dwellings by 2021.	
	Small sites are assumed to be available to accommodate similar amounts of dwellings in the CSR as pre-2016 i.e. about 1/3 of 6200 dwellings including Fenland.	
	Green belt developments identified in the Deposit Structure Plan are assumed to expand to post-2016 capacity, as proposed in the CSR Study and Eastern Cambridge Study.	
	The rest of the required development is assumed to be distributed in market towns, previously established new settlements and rural centres. Dwellings are assumed in Huntington, St. Neots, Ely, Godmanchester and Cambourne. The same 11 rural centres are also assumed to have some development. Out of county market towns are assumed to have the same increase as 2011-2016 in the Deposit Structure Plan Test.	
	Castle (NW Cambridge)	750
	E Chesterton (CNF)	100
	Cambridge Airport	3000
	Newmarket Road	1250
	Cherry Hinton	30
	New Settlement	3000
	Market towns and villages	3050
	Rural centres	500
	Small sites	1960
	Out of county market towns	390
Employment	No direct adjustment for zonal employment numbers used in modelling. Adjustment through increased floorspace in certain zones to facilitate employment growth.	
	The number of inactive households was assumed to increase by an average of about 9% every 5 years from 1991 in the Structure Plan tests. The rate of increase rises from +5% in 1991/96 to +17.8% towards the end of the Plan period. Assuming an average rate of increase of 9% after 2016, the proportion of inactive households will increase from 27.48% (2016) to 28.49% by 2021. This would allow for higher activity rate by 2021 as suggested by EED RES Sub-regional Studies Stage 2 Report Draft July 2002.	
	From the above assumptions, non-employed households will form 30.18% of all households by 2021, increasing from 29.25% in 2016.	

Appendix B: Selected Model Results

Car Travel Details

Urban Cambridge Area

Options	Travel Time	Travel Distance	Travel Delay	Average Speed
2001 Base year	100	100	100	100
2016 Base Case: Structure Plan	137	125	167	91
2016 Orbital Option	145	149	168	102
2016 Road Pricing Option	113	122	118	108
2016 Public Transport Option	135	124	164	92
2016 Combined Orbital, Road Pricing & Public Transport Option	116	135	115	117

Notes:
An average speed greater than 100 is a benefit relative to the year 2001base. For the other factors, a score greater than 100 is a disbenefit relative to the year 2001 base.

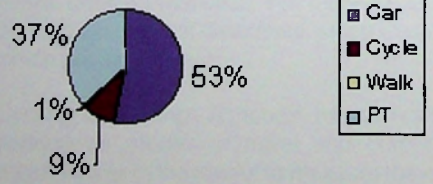
Full Sub-region

Options	Travel Time	Travel Distance	Average Speed	Number of Trips	Fuel Consumption
2001 Base year	100	100	100	100	100
2016 Base Case: Structure Plan	123	117	95	117	131
2016 Orbital Option	125	119	95	118	152
2016 Road Pricing Option	113	113	100	113	121
2016 Public Transport Option	123	117	95	116	131
2016 Combined Orbital, Road Pricing & Public Transport Option	115	115	100	114	131

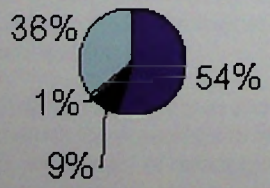
Notes:
An average speed greater than 100 is a benefit relative to the year 2001base. For the other factors, a score greater than 100 is a disbenefit relative to the year 2001 base.

Modal split for trips entering Cambridge 2016, 7 AM to 10 AM

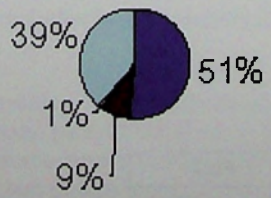
DSP 2016



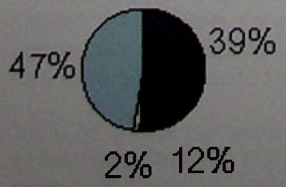
Highways + DSP 2016



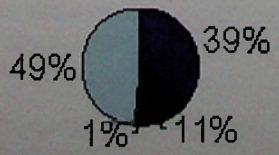
Public Transport + DSP 2016



Congestion Charge + DSP 2016



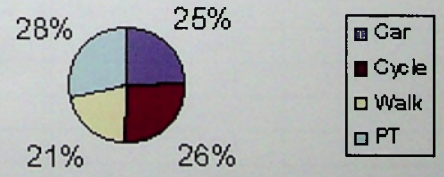
Combined Option + DSP 2016



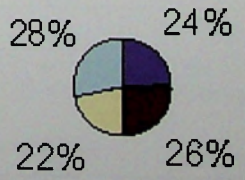
Note: Only the two options that include a congestion charge achieve a significant modal shift from car to public transport.
DSP = Base Case

Modal split for trips within Cambridge 2016, 7 AM to 10 AM

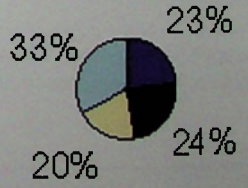
DSP 2016



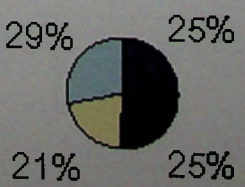
Highways + DSP 2016



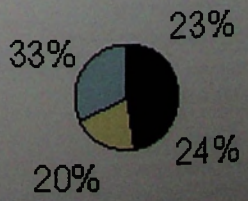
Public Transport + DSP 2016



Congestion Charge + DSP 2016



Combined Option + DSP 2016



Note: The Public Transport and the Combined Option increase the percentage of people using public transport for trips with an origin and destination in Cambridge.
DSP = Base Case

HIGHWAYS OPTION 2016 FLOWS
(AM Peak Hour)

Approximate alignment of new carriageway

Extra lane added to existing road

Existing park and ride site

COMBINED OPTION 2016
TRAFFIC FLOWS (AM Peak Hour)

Approximate alignment of new carriageway

Extra lane added to existing road

Existing park and ride site

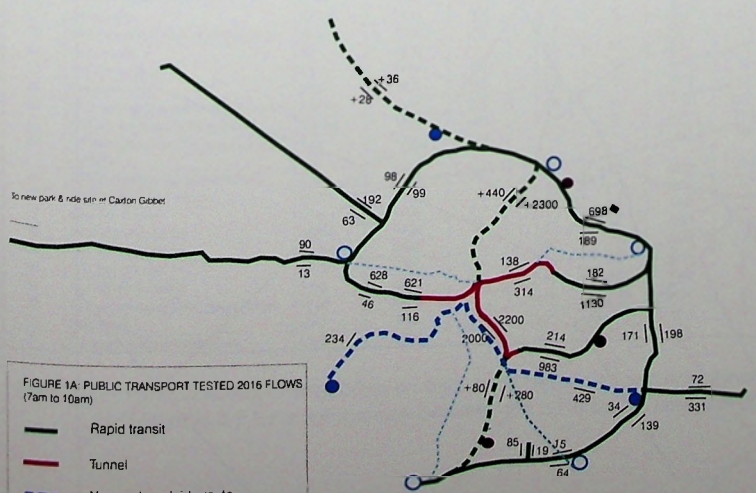


FIGURE 1A: PUBLIC TRANSPORT TESTED 2016 FLOWS
(7am to 10am)

Rapid transit

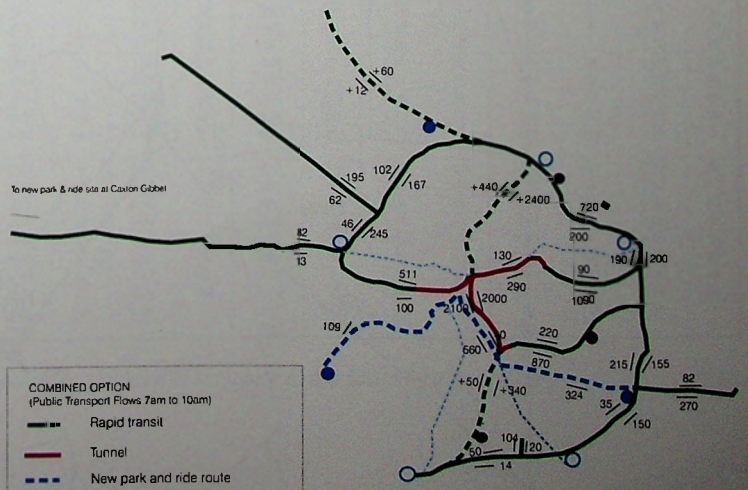
Tunnel

New park and ride route

CHUMMS rapid transit proposals

New rail station

New park and ride site



COMBINED OPTION
(Public Transport Flows 7am to 10am)

Rapid transit

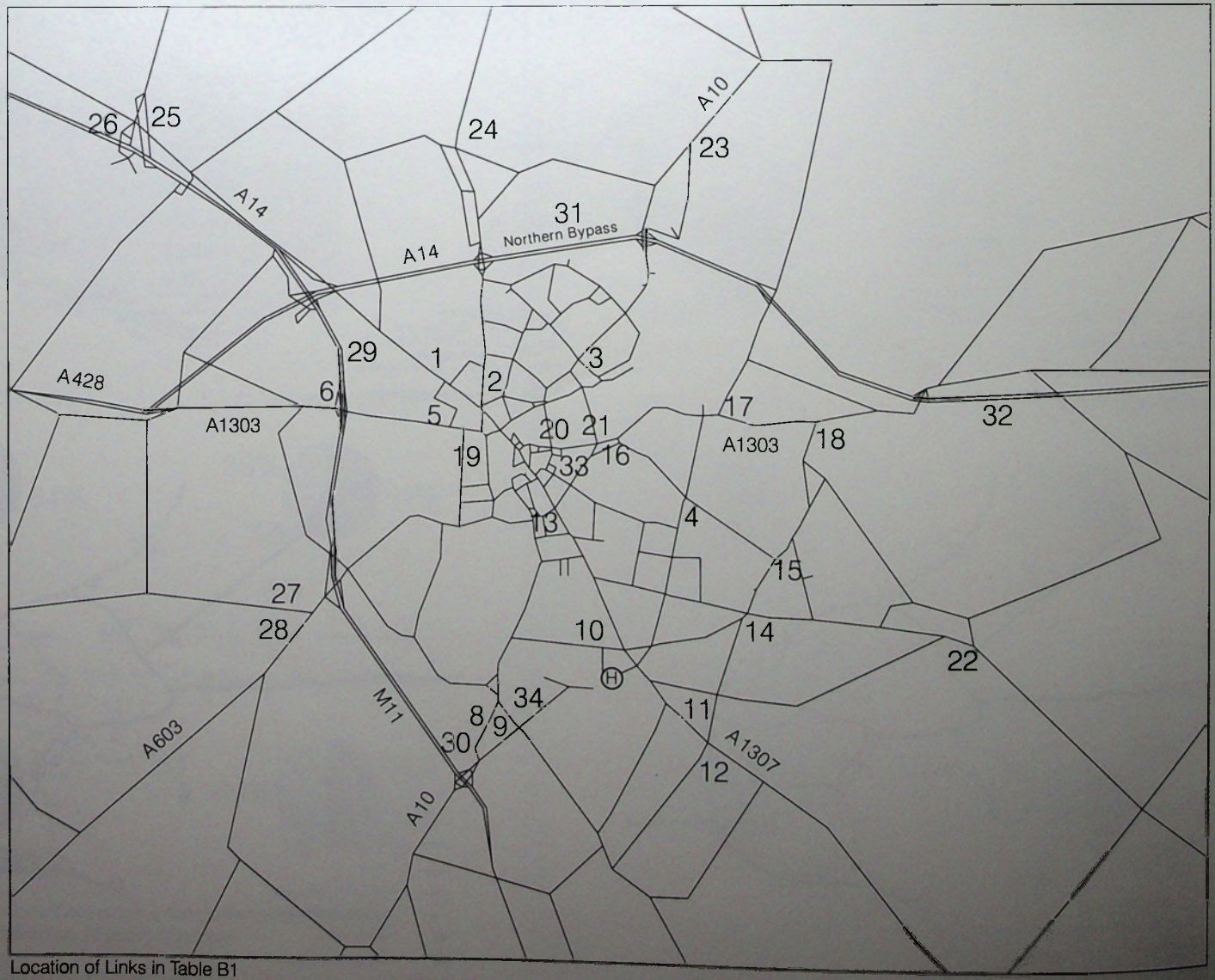
Tunnel

New park and ride route

CHUMMS rapid transit proposals

New rail station

New park and ride site



Location of Links in Table B1

Table B.1: Traffic flows on road links

Link			2016 -Base Case				2016 - Orbital Option				2016 - Road Pricing Option				2016 - Public Transport Option				2016 - Combined Option			
Link ID		Direction	Demand Flow (PCU/ hr)	Delay (secs)	Demand Flow/ capacity	Av Speed (kph)	Demand Flow (PCU/hr)	Delay (secs)	Demand Flow/ Capacity	Av Speed (kph)	Demand Flow (PCU/hr)	Delay (secs)	Demand Flow/ Capacity	Av Speed (kph)	Demand Flow (PCU/hr)	Delay (secs)	Demand Flow/ Capacity	Av Speed (kph)	Demand Flow (PCU/hr)	Delay (secs)	Demand Flow/ Capacity	Av Speed (kph)
1	Huntingdon Rd	E'bd	1647	228	1.18	13	1610	199	1.15	15	973	21	0.69	46	1640	223	1.17	14	993	21	0.71	46
2	Histon Rd	S'bd	995	67	0.80	2	939	44	0.75	3	713	30	0.57	4	1200	83	0.96	2	773	26	0.62	5
3	Milton Rd	S'bd	994	278	0.97	3	892	84	0.85	9	850	62	0.86	11	906	98	0.88	8	654	35	0.63	16
4	Coldhams Lane (East of Barnwell Rd)	NW'bd	731	184	1.13	19	787	24	0.98	38	584	22	0.88	39	701	84	1.07	28	591	11	0.74	42
5	Madingley Rd east of M11 jcn 13	E'bd	1394	14	1.00	46	1284	23	0.92	40	987	10	0.70	49	1536	18	1.10	43	653	8	0.47	52
6	Madingley Rd west of M11jcn 13	E'bd	1731	454	1.24	4	1565	242	1.12	7	1403	35	1.00	32	1708	426	1.22	4	1223	15	0.87	50
7	Barton Rd through Newnham	E'bd	923	262	1.15	5	829	5	0.69	39	697	3	0.58	41	925	264	1.15	5	502	3	0.42	42
8	Hauxton Rd	NE'bd	1157	141	0.73	8	2020	185	1.19	6	988	46	0.55	18	1166	108	0.75	10	1607	269	0.87	5
9	Shelford Rd (adjoining Trumpington High St)	NW'bd	817	260	1.09	5	668	244	0.89	5	640	217	0.85	6	793	232	1.06	5	359	48	0.48	18
10	Long Rd	E'bd	379	6	0.23	53	143	3	0.08	57	165	3	0.09	57	381	5	0.23	54	186	2	0.09	58
11	Queen Edith's Way	W'bd	292	155	1.07	8	292	184	1.08	7	253	57	0.74	17	286	148	1.07	9	214	49	0.59	18
12	Babraham Rd, (nr Addenbrookes)	NW'bd	917	168	1.07	4	1518	32	1.08	17	509	6	0.41	41	982	100	1.03	6	573	5	0.41	43
13	Hills Rd (Nr Lensfield Rd)	NW'bd	563	123	0.78	11	584	130	0.81	10	547	115	0.76	11	565	131	0.78	10	532	100	0.74	12
14	Fulbourne Rd (Nr Cherry Hinton High St)	W'bd	1374	121	1.05	8	1168	16	0.81	29	310	9	0.21	34	1368	110	1.04	9	196	8	0.13	35
15	Cherry Hinton Rd (Church End, Cherry Hinton)	SW'bd	996	177	1.07	5	737	90	1.04	9	933	12	0.91	29	1016	171	1.07	5	688	8	0.78	33
16	Newmarket Rd (adjoining East Rd)	W'bd	1358	95	1.09	10	1248	90	1.08	10	1282	35	0.97	20	1410	119	1.10	8	1276	40	0.99	18
17	Ditton Lane	SW'bd	1028	347	1.18	4	949	112	1.09	10	803	54	0.92	16	1032	357	1.18	4	793	52	0.91	17
18	Newmarket Rd (East of Airport Way)	W'bd	1438	292	1.15	11	1221	33	1.01	5	1256	31	1.00	50	1448	307	1.16	10	1165	3	0.65	36
19	Queen's Rd	S'bd	1900	4	0.96	43	810	2	0.41	44	1522	3	0.77	43	1752	3	0.89	43	723	1	0.36	44
20	Victoria Avenue	S'bd	1486	187	1.20	11	1498	180	1.22	11	1301	66	1.06	21	1466	37	1.19	28	1268	28	1.04	30
21	Elizabeth Way	S'bd	1941	192	1.23	8	2116	60	1.25	19	1754	61	1.07	18	1857	25	1.17	28	1696	22	1.02	30
22	Balsham Rd (approaching Fulbourne)	NW'bd	1016	152	1.06	35	818	39	0.85	55	831	40	0.87	55	1016	152	1.06	35	787	37	0.82	56
23	A10 Ely Rd (approaching Milton)	SW'bd	1614	305	1.15	18	1647	348	1.18	16	1595	280	1.14	19	1639	337	1.17	17	1690	402	1.21	15
24	B1049 Cottenham Rd (approaching Histon)	S'bd	1226	274	1.12	1	1245	300	1.14	1	1154	182	1.07	2	1217	262	1.12	1	1188	243	1.11	1
25	B1050 Hatton's Rd (jcn with A14)	S'bd	2274	38	0.66	58	2215	218	0.70	23	2328	4	0.61	82	2278	54	0.66	51	2317	191	0.72	25
26	A14 (West of Bar Hill jcn)	SE'bd	2961	4	0.55	113	3550	9	0.64	110	2578	2	0.47	114	2957	4	0.55	113	3115	5	0.57	112
27	New Rd, Barton	E'bd	1002	113	1.04	39	980	73	1.02	47	572	19	0.60	64	1003	114	1.04	39	639	21	0.67	63
28	A603 Cambridge Rd	NE'bd	1418	38	1.01	44	1411	28	1.01	51	1159	12	0.83	67	1436	62	1.03	34	1044	10	0.75	68
29	M11 jcn 14 to jcn 13	SE'bd	2883	1	0.69	110	3808	4	0.91	97	3312	2	0.79	103	2929	1	0.70	109	4259	6	1.01	85
30	M11 jcn 12 to jcn 11	SE'bd	3000	8	0.72	107	3317	18	0.81	98	3020	47	0.84	78	3084	10	0.75	105	3361	42	0.82	80
31	A14 Histon to Milton	E'bd	3732	7	0.60	92	4140	11	0.67	88	2916	34	0.57	68	3590	5	0.58	95	3120	2	0.50	99
32	A14 approaching Newmarket Rd jcn	W'bd	2623	7	0.66	99	3497	32	0.87	88	2318	4	0.58	100	2665	8	0.67	98	2940	13	0.74	96
33	East Road	S'bd	845	154	1.07	7	869	159	1.07	7	773	156	0.97	7	832	142	1.06	8	784	138	0.91	8
34	Proposed Addenbrookes Link	E'bd	1700				N/A				1600				1750				N/A			

Note: (a) Traffic conditions deteriorate on links once Demand flow/capacity exceeds 0.85 (congestion at junctions is simulated in the SATURN traffic model).
(b) See table 2.8 for a comparison between the 2016 Base Case and 2001 Base.

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